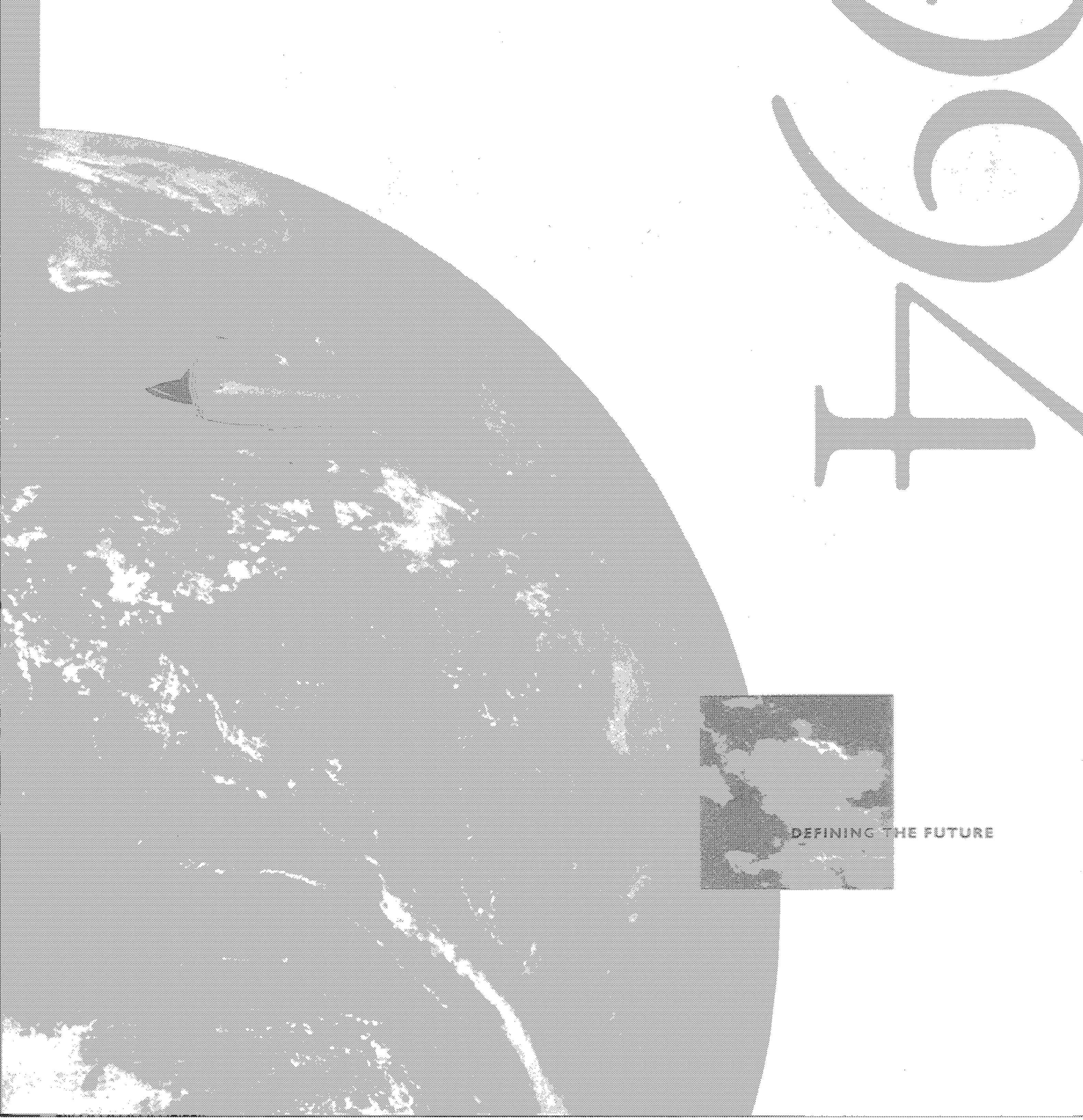
DEFINING THE FUTURE

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fields, and a long look within FAA, the plan sets forth the mission, vision, and values FAA will adhere to. It discusses the forces that will drive FAA action in the future aviation environment. It presents the key issues FAA must face, the goals and objectives FAA will accomplish, and the commitment FAA makes to achieving results.

Volume 2 details some 350 specific milestones FAA will achieve over the next five years. They do not represent everything important FAA will do over the next five years. Rather, they represent actions that meet aviation community concerns. Volume 2 especially responds to the chief concern expressed by aviation; that FAA should not just plan, but should act quickly and decisively to gain high payoffs.

The Appendix describes FAA's evolving future operational concept and the future air traffic management system. In detailed terms, it describes the future FAA is building.

FAA's future concept is, of course, evolving. There is not complete agreement on every detail of the system toward which FAA is building. The vision presented on the pages that follow must be considered only today's snapshot of the future. It will probably be obsolescent in some subtle ways even when the first of you reads it. It will certainly change as new opportunities present themselves, as research reveals both capabilities and limitations of possible technologies and processes, and as system users' wants and needs clarify and change. Nevertheless, what follows is the best and most extensive presentation currently available of the aviation system toward which FAA is building.

and strategies of the FAA Strategic Plan and the specific actions and projects in numerous operating-level plans throughout the FAA. It does this by delineating the operational capabilities that must be in place to achieve the 2010 vision of the future. Second, it does so for the first time from an integrated operating perspective, from the perspective of those who actually provide FAA services to the aviation public. Third, it proceeds from a coherent, agency wide operating vision of the future that sets FAA operational goals for the year 2010. Fourth, it highlights key issues FAA must address to gain the operational goals we have set. Finally, it lays an important foundation for revising the FAA Strategic Plan in light of new FAA leadership and the ever-changing aviation environment.

This document is the product of a dynamic, new process that has generated a great deal of energy throughout the FAA and will continue to evolve as requirements change. The document reflects an attempt to balance the requirements of all members of the aviation community. Driven by the Operational Planning Management Team (OPMT), the new process has focused energy on addressing key issues affecting the agency today and in the future, and on challenging the basic assumptions on which this agency has historically operated. The new FAA Operational Concept is a key step in that process which will continue to involve FAA's customers and leaders in improving FAA services for the future air traffic environment.

a final view of the system. It is intended as a starting point for gaining wide spread external and internal FAA review so that in partnership the FAA and all users of the National Airspace System (NAS) can shape the operational future of our aviation system. Thus, the next edition (1994) of the FAA Operational Concept will reflect the additional comments gathered from the aviation community and revisions from higher level documents such as the FAA Strategic Plan.

Presently the FAA has many elements of an effective planning process. The FAA Strategic Plan identifies major issues and sets forth broad policies and strategies to achieve them. Additionally, there are some 50 other more detailed planning documents, for example: budget related documents like the $30 billion Aviation System Capital Investment Plan (CIP), technically generated documents like the Future of Oceanic Air Traffic Management: A Shared Vision, program related documents like the General Aviation Action Plan, and many organizationally related documents like the Airways Facilities Strategic Plan. (See Figure 1, Before the Operational Concept.)

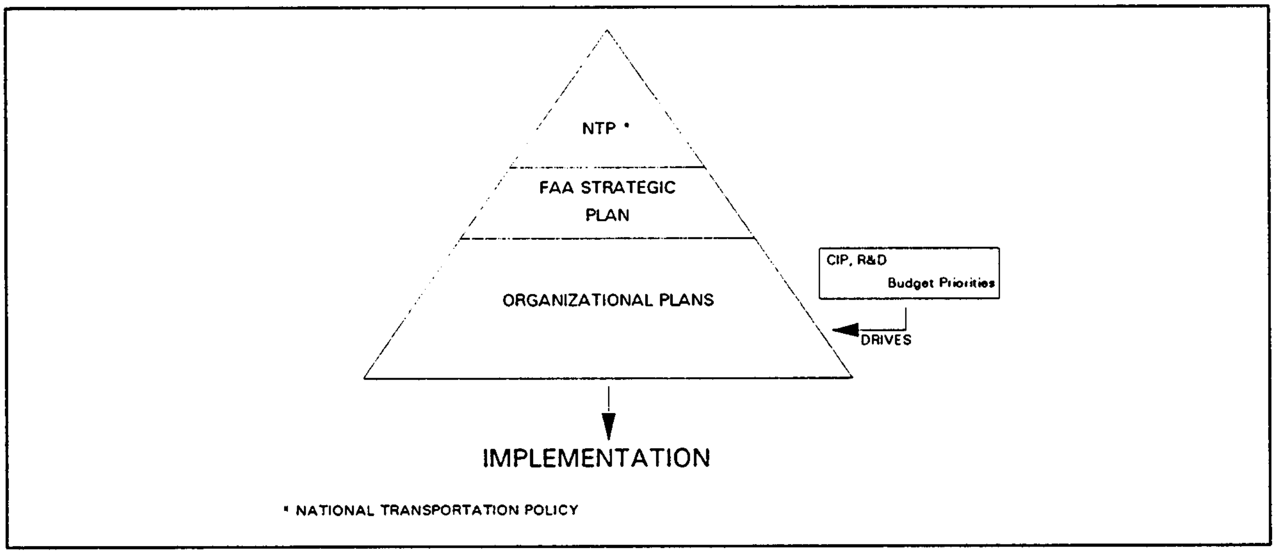

Figure 1. Before the Operational Concept

This document attempts to bridge the vertical gaps between the many individual plans and to horizontally integrate the operational-level plans so that they support each other and move forward with the same basic assumptions and timelines. Detailed schedules and milestones can be found in the individual organization's operational plans. (See Figure 2, After the Operational Concept.)

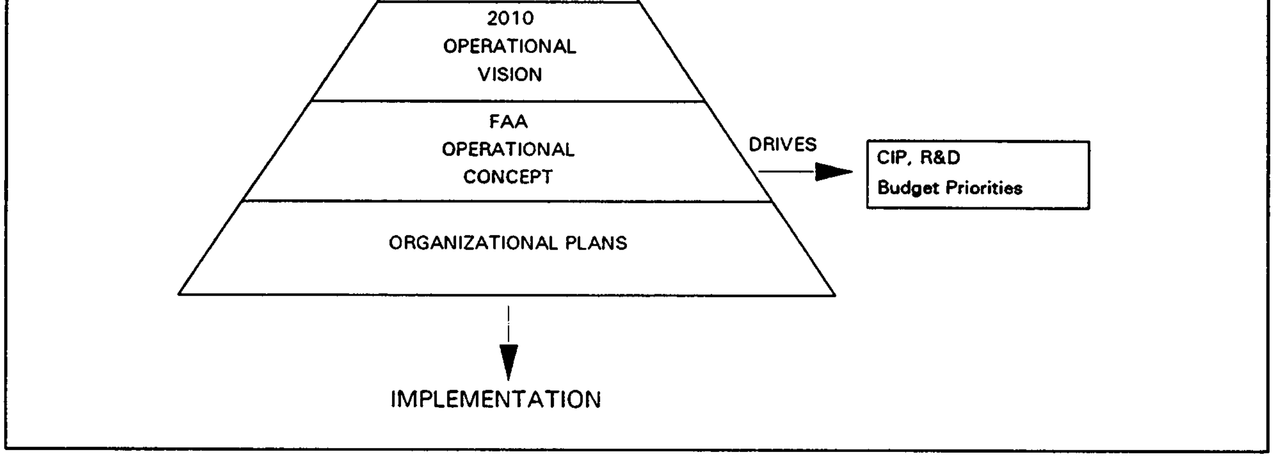

Figure 2. After the Operational Concept

1.2 OPERATIONAL CONCEPT ASSUMPTIONS

The key assumption underlying this document is that FAA can no longer afford "business as usual." FAA has successfully helped create the safest, most efficient aviation system in the world. That system, however, is larger, more complicated, and more global than ever. The FAA must include the aviation community to think further ahead, and improve productivity and efficiency to achieve our goals with the resources we will have. We must move away from an incremental, "bottom-up" approach to an integrated, strategic, "top down" way of thinking that sets a long-range vision. Thus making the hard choices that separate requirements from the "nice to haves." This document assumes we need to constantly challenge everything we do. We need to focus on achieving our goals, avoiding waste and duplication, and working well and efficiently. The products, services, or capabilities enumerated in the vision represent the end result of an implementation process that, in ascending levels of detail, will be spelled out in the agency's strategic, operational, and individual organizational plans.

1.3 THE OPERATIONAL PLANNING MISSION

The mission of operational planning is to unify FAA planning so that we build and operate the best possible aviation system. Such planning proceeds from a common vision of the future, sets policies, strategies, and operational goals, then details in many coordinated documents the actions and projects that will achieve them. It takes an operational perspective, supporting all the ways FAA operates to achieve its vision.

operational plan for the future.

1.5 PROCESS, FLOW, AND SYSTEM PARTICIPANTS

The OPMT has put enormous energy into its mission. It has examined all aspects of FAA and the aviation environment, developed an operational vision of the future, identified and resolved critical issues facing the agency, and organized Issue Working Groups (IWGs) to address the various issues. The IWGs represented all parts of FAA, and also included people from outside the agency (e.g., from the Office of the Secretary of Transportation (OST) and the aviation community) affected by a particular issue. For instance, one IWG expanded the OPMT vision into the mission, vision, and operational goals in this document. That vision was taken to the full Administrator's Management Team and to the aviation community. This document has been coordinated with the aviation community (including the Department of Defense (DOD)).

The goal of the OPMT is to institutionalize a continuing process of identifying issues, bringing together key people to address them, then proposing changes to move the aviation system toward our desired vision of the future. This document is not an end product, but an interim report presenting a current desired vision of the future and the goals, plans, and actions we are taking now to achieve that vision.

1.6 OFFICE OF PRIMARY RESPONSIBILITY FOR SYSTEM TRANSITION ELEMENTS

Sections 3, 4, and 5 contain system transition elements, which are broad descriptors of the anticipated end state conditions of various components of the system, organization, and environment of our aviation world.

Each system transition element is assigned an Office of Primary Responsibility (OPR). The OPR is the focal point for ensuring the elements of the plan are successfully accomplished. Obviously, the OPR cannot do this alone. All interested stakeholders and external customers will be included by the OPR, to aid in the concept's completion.

efficient air transportation system is a prerequisite for national defense and a healthy U.S. economy.

Aviation-related activity (passenger and freight transport, tourism, aircraft design and manufacturing, and aviation infrastructure) contributes roughly half a trillion dollars yearly to the U.S. economy. The sector provides some nine million jobs and five percent of all U.S. wages and salaries. It generates three times the employment in agriculture, electronics, or textiles, and more than 10 times the number employed in either automobiles or steel. For 1992, the U.S. aerospace sector was expected to generate a trade surplus of $31 billion based on exports of $44.5 billion. For every one billion dollars worth of aeronautical products shipped, nearly 35,000 domestic jobs were generated.

In the year 2010, more people will be flying, more often, to more places than ever before. U.S. airlines will carry more than one billion passengers, and operations by general aviation aircraft will increase by 44 percent to 43 million flight hours annually. Thus, the demand for FAA-provided services will increase dramatically. The challenge in the year 2010 will be to ensure these flights are conducted with unprecedented levels of safety, security, and efficiency; that the environmental consequences will be acceptable; and natural resources will be conserved. To ensure the continued effectiveness of the aviation system, FAA must have a vision of the desired future state of the system. In addition, the agency must focus on achieving the goals necessary to realize its part in this vision.

This text provides such a vision for the year 2010. It is intended that the vision be used:

- As a basis for focusing and agreeing on strategic directions and goals with customers, stakeholders, and the people of FAA

- As a principal foundation for the agency's strategic plan

- As a reference guide for agency operational, facility, and Research and Development (R&D) planning and for day-to-day decision making.

The agency plans derived from this document will describe the programs and actions for achieving the vision.

Some of the goals described herein will not be achieved in their entirety and some complicate the achievement of others. For example, one goal is no successful terrorist or criminal act committed against civil aviation. Another is that airport security systems do not hamper passenger processing in terminal buildings. For now and the foreseeable future, these goals conflict. In cases like this, planners and decision makers must strive to achieve a balance. Notwithstanding these limitations, the agency is committed to the goals described herein.

The 2010 vision is organized into 4 distinct sections. Section 2.2 summarizes FAA's mission. Section 2.3 describes the principal external factors that will drive the year 2010 aviation system. It also provides an overview of the context within which the system will function. Section 2.4 then outlines FAA's vision of the aviation system in the year 2010. This vision summarizes what the agency believes must be achieved if the system is to meet worldwide requirements for safe, secure, efficient, and environmentally compatible aircraft operations. Finally, Section 2.5 describes the operational goals FAA is striving to achieve by the year 2010 and outlines approaches to be taken in achieving them. These goals are consistent with FAA's mission and represent agency contributions in manages the world's busiest Air Traffic Management (ATM) system. In a single day, FAA air traffic controllers handle more than 200,000 takeoffs and landings at 17,600 airports across the nation while FAA technicians maintain more than 40,000 communication, navigation, surveillance and automation facilities. FAA personnel--controllers, technicians, and safety inspectors--foster the safety of half a billion airline passenger trips a year as well as the safety of general aviation aircraft operations totaling more than 30 million flight hours annually. In a year, FAA specialists perform 30,000 security inspections and assessments, host more than 5,000 safety seminars, and conduct 300,000 safety inspections of airlines and aviation activities. Certification engineers and inspectors approve new aircraft designs and modifications and perform safety inspections and facility evaluations annually. FAA also maintains a comprehensive program to ensure the security of its facilities and activities in support of the NAS.

FAA's basic responsibilities are spelled out in the Federal Aviation Act of 1958, as amended. They focus on:

- The development and operation of a common system of ATM and navigation for military and civil aircraft
- The control of navigable airspace in the U.S. and the regulation of civil and military operations in this airspace in the interest of safety and efficiency
- The regulation of air commerce to best promote its development and safety and to fulfill the requirements of national defense
- The consolidation of R&D on air navigation facilities, as well as their installation, operation, and maintenance
- The promotion, encouragement, and development of civil aeronautics
- Development of safety standards for the design, manufacture, operation, and maintenance of civil aircraft products.

This core FAA mission has broadened and expanded over the past 35 years to include responsibilities for the development and enforcement of regulations to combat hijacking and other criminal acts against civil aviation. Regulatory responsibility was added to control aircraft noise and other harmful environmental effects of civil aviation, including the disposal of hazardous wastes. These additional responsibilities are defined in various statutes, including:

- The Aviation Safety and Noise Abatement Act of 1979
- The Airport and Airway Improvement Act of 1982, as amended
- The Aviation Safety Research Act of 1988
- The Aviation Safety and Capacity Expansion Act of 1990
- The Airport Noise and Capacity Act of 1990

Manage domestic and oceanic air traffic based on a network of airport traffic control towers, air route and oceanic traffic control centers, and flight service stations.

- Manage airspace and air traffic to meet national defense requirements.

- Develop air traffic rules and procedures and allocate the use of navigable airspace in the U.S.

2.2.2 Airway Facilities and Equipment

- Develop and implement an on-going modernization program to ensure that FAA facilities, equipment, and services cost effectively meet customer requirements for ATM into the 21st century.

- Establish and maintain a nationwide network of communication, navigation, surveillance, and automation facilities to support the ATM process.

2.2.3 Standards and Regulations

- Develop rules, regulations, and minimum standards to facilitate the design, manufacture, operation, and maintenance of aircraft and aviation products, as well as the rating and certification of airmen and designees.

- Develop and enforce rules to protect users of the nation's aviation system from hijacking or other criminal acts against aviation. This responsibility includes regulations requiring inspection of carry-on baggage and screening of all boarding passengers.

- Certify air carriers and airports that serve U.S. airlines and other major carriers.

- Participate with the National Transportation Safety Board in accident investigations.

- Develop and enforce regulations under the Hazardous Materials Transportation Act applicable to shipments by air.

- Set the criteria and oversee the quality checks of navigation, communication, and surveillance system of air navigation facilities in the U.S. and abroad as required.

- Ensure that issues standards and regulations stimulate international competitiveness and do not hinder economic growth.

2.2.4 Airport Programs

- Administer a grant program for the planning and development of public use airports which promotes safety and meets airport capacity needs.

- Develop standards and technical guidance on airport planning, design, safety, and operations.

- Conduct R&D programs and activities directed at providing the systems, procedures, facilities, and equipment needed for a safe and efficient air navigation and ATM system.

- Perform aeromedical research to promote the health, safety, and efficiency of those using, as well as those operating and maintaining the aviation system.

- Conduct R&D programs focused on safer, cleaner, quieter, more efficient aircraft, engines, and aviation products.

- Develop technologies and methods to assess the risk of and prevent defects, failures, and malfunctions of products, parts, processes, and articles manufactured for use in aircraft, aircraft engines, propellers, and appliances which could result in a catastrophic failure of an aircraft.

- Conduct R&D programs focused on Air Traffic Control (ATC), security and aircraft research which:

  - Develop technologies
  - Conduct data analyses for predicting the effects of aircraft design, maintenance, testing, wear, and fatigue on the life of aircraft and on air safety
  - Develop methods of analyzing and improving aircraft maintenance technology an practices (including nondestructive evaluation of aircraft structures)
  - Assess the fire and smoke resistance of aircraft materials
  - Develop improved fire and smoke resistant materials for aircraft interiors
  - Develop and improve fire and smoke containment systems for inflight aircraft fires
  - Develop advanced aircraft fuels with low flammability and technologies for containment of aircraft fuels for the purpose of minimizing post-crash fire hazards.

- Make grants to colleges, universities, and nonprofit research organizations to conduct aviation research.

2.2.6 International Aviation

- Work with aviation authorities around the world to harmonize standards, practices, and procedures as aviation increasingly becomes a global enterprise without national boundaries.

- Negotiate bilateral and multilateral airworthiness agreements to facilitate the import and export of aircraft and other aeronautical products.

- Provide technical assistance and training abroad in areas of the agency's expertise.

- Represent the U.S. in the International Civil Aviation Organization (ICAO) and other international forums.

the year 2010 indicate:

- World revenue passenger miles will increase by 200 percent reaching 3.2 trillion

- Global air cargo revenue ton miles will grow by 136 percent totalling 130 billion

- The market for new aircraft over the next 20 years will be almost one trillion dollars, more than double the market over the past 20 years.

2.3.1.2 Domestic Demand: FAA's long-range forecast of U.S. domestic demand predicts:

- U.S. domestic enplanements will double and commuter/regional enplanements will triple, together totalling over one billion in the year 2010.

- The general aviation fleet will increase by nine percent, to 231,700 aircraft, and operations will jump by 44 percent, totaling 43 million flight hours annually.

- FAA airport tower and en route center operations will increase 40 percent.

- Larger aircraft sizes and higher load factors will combine to prevent even bigger increases.

2.3.2 Aircraft Fleets

A wide diversity of civil and military aircraft types need to be accommodated.

- Airline inventories will increase by 50 percent and include larger, heavier aircraft (600-1000 passengers) and second-generation supersonic transports. Subsonic aircraft will comprise the bulk of the fleet with twin-engine widebodies serving as the airline workhorses.

- The size of the regional/commuter airline fleet will double and include a mix of sophisticated fanjet, propjet, and turboprop aircraft. Most regional aircraft will operate in the 300-400 knot range, improving service to smaller communities.

- Helicopters and new tiltrotor and tiltwing aircraft will play an increasingly important role in providing short-haul and medium-range passenger service.

- General aviation will be a vibrant sector of business and recreational activity. Aircraft will include gliders, balloons, and powered vehicles ranging from homebuilts to increased utilization of sophisticated turbine-powered business aircraft. The number of jet-powered aircraft in the business fleet will grow by 50 percent.

- The number of military aircraft and military aircraft operations will remain essentially constant at their 1992 levels. The military will continue to have unique operational and training requirements that must be accommodated.

- Similarly, international partnerships and interline agreements among air carriers will be pervasive.
- International flights will have unrestricted access to domestic airports around the world.
- Seamless ATM will be provided worldwide (i.e., the ability to fly from one country's ATC system to another will be transparent to the user)

2.3.4 Technological Opportunities

There will be an accelerating explosion of technological opportunities for aeronautical products, services, airports, and ATM, including spinoffs into non-aeronautical activities. Some of these opportunities will include:

- Computers and automation including artificial intelligence
- Human factors and training
- Aerodynamics, structures, and materials
- Aircraft engines and fuels
- Aircraft control systems including full-authority fly-by-light
- Aircraft systems to support operations more integrated with the ground-based ATM system including sophisticated flight management computer systems
- Communications including air-ground data link and satellite relays
- Navigation satellites
- Surveillance including Automatic Dependent Surveillance (ADS)
- Weather observation and forecasting
- Environmental technology
- Airport pavement and systems
- Avionics
- Aviation security technology for screening, access control, explosives detection, and aircraft hardening
- Mapping and charting
- Automated manufacturing and inspection facility with computerized records and data systems.

2.3.5 Environmental Constraints

Increasingly stringent environmental performance requirements will be imposed on aviation, particularly in the areas of noise, air pollution (especially nitrogen oxides), water pollution, hazardous substances, preservation of ecologically sensitive areas, and preservation of stratospheric ozone, and facility environmental compliance.

2.3.6 Financial Resources

Competition for financial resources will intensify and requirements for cost effectiveness will increase as well.

- There will be increasing demand for cost-effective transportation services both to support business and industry activities and to service recreational travel. The aviation system will be in competition with the other modes to provide cost-effective solutions.

- There will be intense international cost competition among suppliers of aeronautical products and among carriers.

- Reduction of the U.S. budget deficit increasingly will be a national priority resulting in growing pressure to constrain government (including FAA) expenditures.

2.3.7 Demographics

- There will be a greater proportion of women in the workforce, over 45 percent by 2000, and far greater cultural diversity as well.

- Fewer new workers will be entering the workforce and the workforce will be aging.

- A greater percentage of new workers will be inadequately educated requiring emphasis on:

    - Using "simplifying" technologies to make up for lack of skills
    - More employer-provided training.

- Increased demand for skilled workers will require more emphasis on programs to attract and retain skilled employees.

2.4 VISION OF 2010 AVIATION SYSTEM

The FAA vision of the aviation system in the year 2010 is to anticipate and meet customer requirements, including the needs of:

- The traveling public

- Operators of commercial, business, and general aviation aircraft

- Airmen (pilots, maintenance personnel, etc.).

Additional stakeholders in FAA are suppliers, regulators, groups affected by aviation (e.g., noise), OST, Congress, the financial community, the U.S. taxpayer and the U.S. economy, which is dependent upon air transportation for domestic prosperity and world competitiveness.

2.4.1 Safety and Security

The principal goals are:

- No fatal accidents in air transportation

- No successful terrorist or criminal acts committed against civil aviation, including people, aircraft, airports, facilities, and equipment

- No aircraft design flaws or manufacturing defects.

2.4.2 Capacity

- Airspace, airport and airside capacity continues to grow to cost effectively meet user needs

- Fully utilizing capacity resources to meet traffic demand and eliminate capacity-related delays

- Capacity in Instrument Meteorological Conditions (IMC) equal to Visual Meteorological Condition (VMC) capacity at U.S. airports.

2.4.3 Efficiency

- Air travel cost effective and competitive with other modes

- Service on time

- Aviation system productive in its utilization of capital and manpower resources

- Service without equal, providing nationwide/worldwide coverage

- Air travel which is convenient and comfortable

- New aircraft and support service deliveries on time.

2.4.5 Environment

- Aircraft noise and impact on air quality within acceptable bounds
- Energy efficient air transportation system
- Hazardous materials and wastes properly controlled
- System environmentally acceptable

2.4.6 Technologically Advanced

- Aviation system which cost effectively exploits and embodies current technology
- Design and manufacturing technologies that generate current aircraft

2.5 FAA OPERATIONAL GOALS FOR THE YEAR 2010

2.5.1 Air Carrier and General Aviation Operations

2.5.1.1 FAA Operational Goals

Air carriers, other operators, and airmen operate with high levels of safety and no fatal accidents in air transportation.

Full compliance with Federal Aviation Regulations (FAR) and other standards are achieved while minimizing the cost impacts on the user and the FAA.

2.5.1.2 Approach to Achieving the Goals

FAA, in partnership with the aviation community, will:

- Reduce the regulatory burden on airmen and operators by evaluating the effectiveness of existing rules and procedures and modifying or eliminating those which impose burdens without commensurate safety gains.
- Develop and implement joint agendas and action plans with the aviation community to maximize user involvement in identifying and resolving safety and other issues and minimizing expenditures of FAA resources.
- Implement alternative approaches in achieving compliance with FARs using techniques such as voluntary self-disclosure, internal evaluation, and remedial training (i.e., "Compliance for the 90's").

- Traffic Flow Management and Separation Services

  - System capacity resources continue to grow and are fully utilized to meet traffic demand
  - System accommodates full range of aircraft types and operators
  - System provides safe separation of aircraft from other aircraft, obstructions, terrain, and hazardous weather
  - Flight paths are users' preferred flight trajectories, i.e., the routes, altitudes, speeds, departure and arrival times meeting their requirements
  - Airspace users are involved in interactive ATM planning and decision making.

- Navigation and Landing Services

  - Navigation accuracy for en route, oceanic, terminal, and non-precision approach operations at 100 meters 95 percent of the time and 300 meters 99.99 percent of the time
  - Precision approach capability provided at all U.S. public landing areas.

- Aviation Information

  - Users have access to required aeronautical information, including:
    * Current weather and forecasts
    * Current and projected traffic congestion and delays
    * Status of FAA facilities, airports, and airspace
    * Local traffic situation relevant to each user's operation
  - Information that is:
    * Accurate (conforms to reality)
    * Reliably available
    * Easily accessed and used
    * Affordable

2.5.2.2 Approach to Achieving the Goals

- The facility modernization program will continue to provide essential improvements in services and automation capabilities as well as provide the infrastructure for future system upgrades.

- New technologies, including satellite-based communications and navigation, data link, Automatic Dependent Surveillance (ADS), and automated weather sensing and prediction will be implemented.

- Airspace structures will be made more flexible, including dynamic civil/military use of special use airspace.

- Separation standards will become more flexible, including application of time-based and distance-based criteria where they are most effective.

- Highly accurate models will be used for intricate planning.

2.6 SYSTEMS OPERATION AND MANAGEMENT

2.6.1 FAA Operational Goal

Ensure the availability of NAS functions and services

2.6.1.1 Approach to Achieving the Goal

- FAA will continue its transition to a concept of system operation and service management, including monitoring, controlling and management, rather than on-site facility maintenance.

- NAS operations command and network control centers will be fully on line by the year 2010 with responsibility for ensuring availability of NAS functions and services.

- Coordinated, real-time remote monitoring, control, and certification functions will be performed from the control centers.

- FAA will employ current system management techniques, where appropriate, including:

  - Fault tolerant designs
  - Redundancy
  - Built-in maintenance tools that allow equipment to be monitored, controlled, and managed by system operators at centralized locations
  - Built-in test equipment
  - Artificial intelligence and expert systems for automatic diagnostics, trend analysis, and failure prediction
  - Automated logistics management and control systems.

- FAA will use these tools and capabilities to:

  - Improve service availability
  - Reduce the need for on-site facility staffing
  - Reduce the need for routine/preventative maintenance
  - Reduce the need for on-site corrective maintenance
  - Allow predictive/preemptive maintenance activities to occur before failure.

- Environmental Impacts

  - Environmental evaluation and mitigation are an integral part of airport operation and expansion so that sustainable growth achieved is consistent with environmental protection

- Airport Costs

  - Airports which are cost effective and affordable

- Airport Security

  - No successful terrorist or criminal acts against aviation in the year 2010. In addition, airport security systems that do not hamper passenger processing through terminals will be in operation.

2.6.2.2 Approach to Achieving the Goals

- Airport Planning and Design

  - In partnership with the aviation community, FAA will provide national leadership to promote and guide airport improvements to satisfy foreseen demand. Improvements will include:
    - Building new airports and new runways at existing facilities
    - Increasing utilization of currently underutilized airports
    - Jointly using active military fields and converting surplus military airports to civil use
    - Implementing specialized systems of airports to serve all new technology aircraft
    - Developing and implementing technological and procedural improvements that expedite traffic flows and increase airport capacity
    - Using demand management techniques, including price/demand management, only where necessary to allocate scarce capacity resources

- FAA will guide, facilitate, and provide incentives for airports and local communities to ensure:

  - Comprehensive environmental evaluation and mitigation built into planning and operation and aircraft design
  - Development of compatible uses to land exposed to high noise levels
  - Appropriate intermodal access to airports to provide efficient ground access while reducing environmental impacts

- FAA will continue to develop and publish cost-effective airport planning and design standards and specifications.

- Upgrading existing facilities to increase the number of general aviation airports capable of serving business jets

- Adequate access by ground transportation modes including public transportation options

- Strengthening runways and taxiways, enlarge fillets, and modify terminals to accommodate larger and supersonic aircraft.

FAA will provide financial assistance for procurement and installation of safety equipment, including:

- Fire and rescue equipment

- Aircraft anti-icing and deicing equipment

- Bird and wildlife controls

- Lighting, marking and signing for runways and taxiways

- Equipment for monitoring and cleaning the runway surface to ensure adequate friction.

FAA will provide technical expertise and financial assistance to enhance the environmental compatibility of airports.

FAA will continue to provide financial assistance for procurement and installation of security equipment for purposes such as access control and perimeter security.

FAA will monitor and publish airport costs to help ensure that airports remain cost effective and affordable.

2.6.2.4 Technology, Standards, and Certification

FAA will continue to develop technology and procedures as well as appropriate standards and regulations for:

- Aviation security

- Airport safety equipment

- Aircraft Safety.

FAA will develop technology and appropriate standards for runway and taxiway pavement to increase design life, reduce pavement maintenance requirements and downtime, and reduce life-cycle costs.

FAA will continue to develop effective regulations, standards, and guidance materials for the certification of airports including periodic inspections.

- Passengers which are better protected by energy absorbing seats and other devices
- Aircraft structures incorporating design features to reduce crash forces on occupants

o Aircraft Structural Integrity

- No in-service structural failures of aircraft or engines, in particular, as a consequence of corrosion or fatigue
- Aircraft structures and cargo/baggage containers incorporating design features which contain bomb blast effects as a means for protecting the aircraft from catastrophic damage
- Aircraft incorporating design features to ensure that failures, including improbable events, do not prevent safe landing of the aircraft

o Aircraft Systems and Equipment Integrity

- Aircraft Ice Protection Systems Technology

o Certification of Aeronautical Products

- Certification standards, practices, and procedures harmonized internationally to improve the efficiency and cost effectiveness of the certification process thus maximizing the extent to which one country's certification is accepted by others
- Certification standards, practices, and procedures paced with technology, product improvements, safety hazards, and industry needs to foster the timely, cost effective introduction of new technologies and aircraft capabilities

o Aircraft/Airport Compatibility

- Aircraft sized to make best use of ATM system capacity resources in meeting cargo and passenger trip demands
- Aircraft physical characteristics compatible with airports
- Aircraft wake vortices minimized in order to reduce separation requirements and maximize the capacities of airspace and runways

2.6.3.2 Approach to Achieving the Goals

FAA will partner with industry, universities, NASA, DOD, and others to develop technology and procedures, as well as appropriate standards and regulations, to enhance aircraft structural integrity and crashworthiness. Therefore improving the protection of passengers from crash forces, fires, and bomb blast effects.

FAA will provide leadership, while working in partnership with the international community, to harmonize certification standards, practices, and procedures.

FAA will exploit industry capabilities for developing and applying certification standards as a means of expediting the certification process to keep pace with technology developments and industry needs. In particular, data

2.6.4 Operational Human Factors and Training

2.6.4.1 FAA Operational Goals

- Aviation Systems are Human-Centered
    - Operate cooperatively with human operators, aiding them in accomplishing their tasks
    - Tolerance of human errors
    - Retain humans "in the loop" as managers and directors of system operation with full situational awareness

- Training
    - Cost effective training technology and materials available and applied to ensure that operational personnel (pilots, controllers, aircraft and FAA maintenance technicians, aviation safety inspectors, and aviation safety engineers) are fully proficient in the knowledge, skills, and abilities required by their jobs

- Workforce Capability
    - Knowledge, skills, and abilities required to operate and maintain FAA systems consistent with the capabilities of the available workforce (as opposed to requiring extensive training to close the gap)

2.6.4.2 Approach to Achieving the Goals

FAA will ensure development of human factors knowledge focused on formulating, validating, and applying human-centered automation design techniques.

FAA will ensure development and application of current training technology and appropriate training standards to ensure proficiency of operational personnel.

FAA will ensure the knowledge, skills, and abilities required of operational personnel by new technology and systems are identified and incorporated into training and personnel selection programs.

FAA will ensure the design and acquisition of NAS equipment takes into account human resource planning and the capabilities of the available workforce and incorporates current technology in human factors and training.

FAA will conduct seminars and other programs to disseminate training materials and information within the aviation community.

FAA will apply current human factors knowledge in establishing regulations and standards.

- Air Quality
    - More efficient engines available commercially to minimize the impact of aircraft on air quality and global ecological conditions
- Impact of FAA Operations
    - The impact of FAA operations on the environment is contained within acceptable bounds

2.6.5.2 Approach to Achieving the Goals

FAA will work in partnership with industry, universities, NASA, DOD, and others with the objective of developing commercially available engine and airframe technologies which reduce the environmental impacts of aircraft operations. Industry and government experts believe the following goals are achievable:

- Noise levels 50 percent lower than Stage 3 standards
- Nitrogen oxide emissions 60 percent lower than 1992 ICAO standard levels with carbon monoxide and hydrocarbon emissions reduced 50 percent
- Fuel consumption per passenger seat mile reduced by 20 percent as compared to 1992 levels.

FAA will assess the environmental consequences of its operations and select alternatives that fulfill mission requirements with the minimum adverse environmental impact, including:

- Locating FAA facilities at sites having the least adverse environmental impact among the operationally acceptable alternatives
- Using predominantly hazard-free electronic equipment in lieu of environmentally unsafe mechanical equipment
- Developing equipment specifications that minimize the quantity and toxicity of hazardous materials used in equipment and equipment maintenance
- Ensuring proper storage and disposal of all hazardous materials.

2.6.6 U.S. Leadership

2.6.6.1 FAA Operational Goals

U.S. continues to be a leader in the cooperative development of a harmonized global air transportation system, with plans to:

- Lead in the development of a seamless ATM global system

- Ensure that U.S. aeronautical, ATM products and air carriers are competitive in world markets.

2.6.6.2 Approach to Achieving the Goal

FAA will provide strong leadership within the aviation community to establish a comprehensive industry/government joint venture to guarantee continued competitiveness of U.S. aviation products and services in an open global marketplace.

FAA will lead by fostering within the U.S., the development and implementation of the most technologically-advanced aviation system in the world with the highest levels of safety, security, efficiency, and environmental compatibility.

FAA will lead in the international harmonization of aviation standards, practices, and procedures to:

- Ensure adequate levels of safety and security for U.S. operators and passengers worldwide
- Reduce certification costs
- Speed the introduction of new technology and aeronautical products
- Promote the acceptance of U.S. products in world markets
- Maximize the extent to which one country's certification will be accepted by others
- Ensure that international standards, practices, and procedures are cost effective.

FAA will continue to provide strong leadership in ICAO to develop a coordinated global plan for the future air navigation system.

FAA will provide strong technical leadership based on its R&D program. In addition, FAA will establish multinational R&D agreements and form international partnerships in technology development and demonstration.

FAA will provide technical information and assistance as well as training to other civil aviation authorities and foreign aircraft operators in order to promote an aviation infrastructure abroad meeting the needs of U.S. operators and passengers.

FAA will assist foreign governments in the specification, procurement, and installation of Airway Facilities (AF) and equipment.

FAA will encourage procurement of U.S. products and services by other countries.

- Listens and responds to customer needs while involving customers in planning and decision making

- Is efficient, productive, and cost effective (business-like), including:

    - Recruitment, training, development, and retention of a diversified workforce of the best-qualified people
    - An effective quality management program
    - Use of current technology to implement innovative service improvements
    - The ability to make and implement tough decisions
    - Effective cost control to ensure that FAA services are cost effective and affordable

- Provides global leadership in promoting civil aviation and aviation technologies

- Coordinates with other modes to foster integrated transportation system development.

2.6.7.2 Approach to Achieving the Goal

In order to achieve the goals, the following conditions must prevail:

- People

    - FAA must compete effectively with the private sector to recruit and retain a diversified workforce of the best-qualified people
    - Salaries, benefits, and rewards must be competitive - especially for people with high technical, operational, and leadership skills
    - Hiring procedures must be flexible, responsive, and timely to meet the needs of new employees
    - Effective training, development, and career progression opportunities must be provided
    - Collaborative labor-management relations must be established and maintained
    - Programs such as child care and alternate work places must be established to accommodate employees' family responsibilities.

- FAA must have an adequate supply of properly educated and trained entry-level people

- FAA must encourage young people to become involved and skilled in aviation

  - * ATM procedures
  - * Certification standards, practices, and procedures
  - * System operation and management
- The FAA organizational structure must be flexible and adaptable to the needs of the customers
- FAA must automate its administrative processes to reduce paperwork and improve efficiency.

- Planning

  - The agency's strategic planning process must provide flexible, integrated, and timely long-range plans that drive FAA's programs and decisions
  - FAA must ensure planning and decision making focus on the technical, operational, and economic needs of the NAS
  - FAA planning must consider all investment options for meeting requirements including technology, airport infrastructure, procedures, and people
  - FAA must establish and maintain a comprehensive, integrated information management capability to support planning and decision making.

- Funding and Budgeting

  - Funding must be adequate to support FAA programs and customer services
  - Funding must be stable and predictable in order to:
    - * Foster effective long-range planning
    - * Minimize energy lost in contingency planning (budget drills)
  - System costs must be fully supported by revenues collected from users
  - The budget process must be flexible and must respond quickly to the changing requirements of a dynamic aviation system, including the need to implement new capabilities not planned years in advance
  - The budget process must be effective in ensuring distribution of resources in accordance with agency priorities and the strategic plan
  - FAA must implement cost monitoring and control capabilities to ensure that services are cost effective and affordable.

- Technology Development and System Acquisition

  - FAA must pursue a broad-based, long-range R&D program in cooperation with other government agencies (NASA, NOAA, DOD), universities, the private sector, and the international community. This R&D program will develop and apply new technologies as a basis for innovative, cost-effective standards and service improvements ensuring the continued safety and efficiency of aircraft operations.
  - FAA must define and reliably carry out a systematic program of NAS service improvement consistent with user needs, user equipment improvements, and the capabilities of the available workforce.
  - FAA must procure and implement current technology in the NAS on a timely basis in order to keep pace with changing system requirements.

and operational impacts as well as the international competitiveness of such rules.

- Regulations and standards must be timely; must keep pace with customer needs, technology, and product improvements; and must be harmonized international

— Decisions on the degree to which Global Navigation Satellite System (GNSS)/ADS can substitute for primary or secondary surveillance radar in en route and terminal airspace. Because of the importance of avionics equipage levels and timing, early assessment and decisions are needed on the prospects of:

- GNSS/ADS as data sources for PRM systems, and data sources for lower cost collision avoidance systems
- On the role of GNSS/ADS or Modes S SSR as a "talking beacon" squitter source
- Least expensive ways to provide data link services to general aviation aircraft
- Optimum future relationship of SSR transponders (ATCRBS or Mode S) and GNSS/ADS transmissions.

— Decisions on the future ATC surveillance system(s) (assuming that primary radar for ATC separation will no longer be used en route) to establish the appropriate future roles of secondary radar in the terminal area and on the airport surface, and to establish requirements for accuracy and update rates for the several surveillance system applications.

— A series of decisions on the need, relocation, decommissioning, and supportability concept of the remaining long range radars on the U.S. borders.

• The shift to a space-based navigation system from a ground-based system requires the FAA to determine the following:

— Decisions on the future utilization of the GNSS, the roles it is expected to play in en route and terminal navigation, non-precision and precision approach and landing, departure and missed approach, airport surface surveillance guidance and navigation, and its role in providing ATC surveillance over oceans and land. A significant part of the issue is the decision on the appropriate process for ensuring system integrity and the need/role for differential correction and back-up/support system requirements in establishing the "sole-source" use of GNSS for various functions, including landing.

— When should each element of the ground-based system be decommissioned (VOR's, NDB's, etc.).

— To expedite this conversion in the most cost beneficial way, the Federal Government must decide if subsidies for avionics installation in civil aircraft are a viable option.

• To reduce operator costs, the FAA must decide that it is feasible to predicate targeted operations inspections based upon risk assessments vis-a-vis a set schedule.

• The FAA needs to decide on the extent of converting its facilities to use digital fiber-optics.

• To reduce the impact of product liability costs, the FAA must decide to actively support actions to mitigate this burden on the aviation community.

• The FAA needs to commit to instituting an integrated strategic and operational planning process.

— The FAA will have to commit to instituting a budget policy responsive to the strategic and operational plans being developed.

• Should the FAA require criminal history checks for airport employees?

- The FAA should once again establish that its charter of fostering and promoting aviation in no way conflicts with its regulatory responsibilities. In fact, it is not possible to foster and promote aviation without adequate safety regulation. Conversely, safety cannot be maintained without fostering and promoting aviation through technological and product innovation, maintenance of a healthy aviation infrastructure, and adequate economic incentives.

- Decisions on the direction of ATC automation services, the integration of the several FAA automation efforts (e.g., flow management automation, en route and terminal area automation, airport surface traffic automation, oceanic automation) and establishment of standards interfaces between them.

- Decisions on the appropriate balance between the separation assurance task of ATC at the scene and the overlying task of providing the least intrusive capacity/flow management when capacity limitations become evident.

- Decisions on the utilization of the elements of an architecturally sound aviation weather system that integrates the FAA and NWS weather modernization programs and aircraft weather/wind data sources, and establishes the interrelations with the automation and technology components of the ATC and air traffic management system.

- Decisions on the ingredients for an airport surface traffic management system, assigning appropriate functions to the several systems elements -- surveillance, visual aids, signage, marking, surface movement guidance and control systems, automated surface traffic management, etc.

- Decisions on what should comprise a rational and cost-effective, legitimate-threat-driven and flexible aviation security system.

- Decision to proceed on establishment of an airport pavement design and management system which enhances the nation's major investment in airports.

- FAA needs to establish an administration-wide policy on risk management and the methods of determination of adequate safety of all FAA and industry practices, with special emphasis on approach procedure criteria and separation standards.

- FAA, in conjunction with NASA and industry, should decide to undertake or sponsor basic technology research to reduce noise and emissions. If noise and engine emission technology are not advanced, environmental regulations could become one of the biggest impediments to growth of the air transportation system.

The expected outcomes of these decisions are reflected in the following operational concept transition elements. The exact nature of each decision and its ramification will be reflected in the day-to-day implementation of each organizations's operational plan.

3.1.1.2 Safety of flight throughout the NAS increases by improving the capability to track aircraft and forecast hazardous weather activity. [OPR = AAT]

3.1.1.3 User preferred flight profiles continue to be provided to aircraft between designated city pairs or in response to individual flight requests. [OPR = AAT]

3.1.1.4 The FAA examines its role in providing weather services and products. [OPR = ASC]

3.1.1.5 Weather information is more reliable as forecasting continues to improve, while using the same methods to access information. [OPR = ASC]

3.1.1.6 Global Positioning System (GPS) approach requirements trigger the need for weather information to meet Part 135 requirements. [OPR = ASC]

3.1.1.7 The development of satellite-based surveillance provides safer and more accurate oceanic ATM and navigation. [OPR = ASD]

3.1.1.8 Establishment of data link communications via VHF radio and satellite provide direct pilot-controller oceanic communication and provide service to aircraft thousands of miles away. [OPR = AAF]

3.1.1.9 Establishment of weather information via VHF radio and satellite provide direct pilot-controller oceanic communication and provide service to aircraft thousands of miles away. [OPR = AAF]

3.1.1.10 The Congressionally-mandated report on ATC data and communications system security is complete. [OPR = ACS]

3.1.2 Quality Assurance

3.1.2.1 The FAA continues to conduct inspections and surveillance of private individuals and organizations to ensure compliance with agency regulations and standards, and to maintain original certification standards. [OPR = AVR]

3.1.2.2 Inspection programs are driven by locally identified perceived safety concerns. [OPR = AVR]

3.1.2.3 The FAA targets inspection resources based upon risk assessment. The application of this new system allows for the reduction and frequency of mandatory inspections of air carriers operating within industry norms. [OPR = AVR]

3.1.2.4 The FAA develops and implements a Screener Performance Evaluation and Reporting System (SPEARS) to detect deficiencies and improve the effectiveness of the screening process through monitoring, testing, and training security personnel. [OPR = ACS]

3.1.3.2 Concurrent with plan approval, the following studies have been initiated: [OPR = AXD-4]

- Error Control and Management System for aircraft
- Human Centered Automation Concepts
- Aircraft situation and environment management
- Airmen Certification for highly automated flight decks
- Air traffic performance enhancements
- Management of ATC information
- Workforce dynamics for systems operations during transition.

3.1.3.3 Increase the testing of security systems under more realistic conditions and address non-traditional threats. [OPR = ACS]

3.1.3.4 Examine the effectiveness of the training regarding access controls and other aspects of FAR Parts 107.14 and 107.25. [OPR = ACS]

3.2 NATIONAL AIRSPACE SYSTEM INFRASTRUCTURE

3.2.1 Systems Support

3.2.1.1 The FAA's ability to reduce the number of costly ground-based navigation and landing systems it must maintain depends upon the rate and extent of GPS equipage by the U.S. Civil Aviation Fleet. The FAA will quickly certify equipment, establish procedures, modify airspace, and provide advisory material. [OPR = AVR]

3.2.1.2 Financial incentives to expedite the conversion (replacement) of installed aircraft navigation systems with GPS are evaluated and, as appropriate, legislative authority to provide such incentives is solicited from Congress. [OPR = API]

3.2.1.3 The FAA establishes an operations concept to manage the future NAS infrastructure and employ command and control technologies. [OPR = AAF]

3.2.1.4 A management information system is developed to consolidate operating, performance, and cost data for distribution to FAA management. [OPR = AIT]

3.2.1.5 The second phase of FAA Maintenance Control Center (MCC) implementation is complete. This allows for reduced preventive maintenance and centralization of functions. [OPR = AAF]

3.2.1.6 The FAA's inventory continues to be managed from a central location. Spares usage is based upon maintenance actions with required depot-level support provided from the same central location. [OPR = AAC]

3.2.1.7 The FAA continues to move towards direct shipment of Commercial-off-the-Shelf (COTS) equipment and completes a study determining how COTS equipment affects maintainability, supportability and funding. [OPR = AAF]

3.2.1.11 Maintenance for the ATC software and hardware is provided on-site with second level engineering support provided from FAA Technical Center for the ATC system and FAA Aeronautical Center for the non-ATC systems. [OPR = AAF]

3.2.1.12 The FAA converts all facilities to digital fiber optics to handle the vast amounts of data required for future ATC systems. [OPR = AND]

3.2.1.13 The FAA initiates an effort to realign the current logistics center and existing AF functions. [OPR = AAC]

3.2.1.14 The AF organization improves its service delivery by realigning its headquarters functions to establish clear responsibilities along service lines. These service lines include: [OPR = AAF]

- Automation systems services
- Communications systems services
- Facility (i.e., Power and Buildings) systems services
- Logistics systems services
- Navigation and landing systems services
- Surveillance systems services
- Weather systems services
- Special programs services
- Operations Control Centers.

3.2.1.15 Increase awareness within the FAA and affected stakeholders of the necessity to preserve, obtain, and protect the aeronautical frequency spectrum. [OPR = AAF]

3.2.1.16 Updated applicable orders in all major programs include operations security, personnel security, communications security and information security. These actions [OPR = ACS]

- Establish current guidelines for major FAA security programs agencywide
- Ensure compliance with national policy and DOT policy.

3.2.1.17 Security management and risk reduction concepts are integrated into new and existing facilities. [OPR = ACS]

3.2.2 Landside/Airside Operations

3.2.2.1 The FAA establishes independent parallel approaches using Precision Runway Monitor (PRM) with a 1 - 2.4 second update rate to allow independent Instrument Landing Systems (ILS) approaches to parallel runways whose centerlines are between 3,000 feet and 4,300 feet apart. [OPR = ASC]

3.2.2.5 The FAA establishes triple approaches. This concept allows the use of two parallel and one converging runway benefitting airports such as Chicago O'Hare and Dallas/Fort Worth. [OPR = ASC]

3.2.2.6 The Facilities and Equipment (F&E) budget process will be more responsive to the pace of military airfield conversions. [OPR = ABU]

3.2.2.7 The FAA works closely with DOD and potential sponsors for the approximately 35 military airports made available. [OPR = ARP]

3.2.2.8 The FAA administers the Airport Improvement Program (AIP) in a way that maximizes the increase in the nation's airport capacity. [OPR = ARP]

3.2.2.9 The FAA increases airport capacity by taking affirmative action to ensure close coordination between projects funded under the AIP and equipment provided through the F&E budget process. [OPR = ARP]

3.2.2.10 The FAA administers airport funding in a manner that maximizes increases in airport capacity. [OPR = ARP]

3.2.2.11 The FAA administers the AIP in a manner which gives due consideration to implementing corrective actions identified by airport capacity design teams improving operational efficiency and reducing delay at airports under study. [OPR = ARP]

3.2.2.12 The FAA prudently applies the AIP's letter-of-intent mechanism to induce airport capacity development. [OPR = ARP]

3.2.2.13 The FAA approves Passenger Facility Charge (PFC) proposals that permit airport capacity development projects to get underway. [OPR = ARP]

3.2.2.14 The rewrite of FAR Part 107 on Airport Security updates the basic security regulation affecting airport operators and individuals present in specified areas of the airport. [OPR = ACS]

3.2.2.15 The rewrite of FAR Part 108 updates the basic regulations affecting air carrier security. [OPR = ACS]

3.2.2.16 The implementation of <u>Airport Design and Construction Guidelines</u> provides an updated and centralized source addressing security concerns during the construction of new airports or the renovation of old ones. [OPR = ARP]

3.2.2.17 "Unescorted Access Privileges" rulemaking (criminal history checks) establishes regulations for an employment investigation used to identify prospective employees who should be subject to a criminal history records check. [OPR = ACS]

3.2.2.18 In coordination with all affected parties, standards are developed for universally accepted ID/access media to alleviate both security and operational concerns associated with the wide variety of equipment, procedures, and technologies currently in use or planned for individual airports. A universal system is more cost

3.2.2.22 The use of combinations of existing detection devices and procedures increases the efficiency and effectiveness of security screening. [OPR = ACS]

3.2.2.23 The FAA develops survivability standards for new aircraft and hardening standards for baggage containers to enhance the ability of the aircraft to survive an on-board explosion. [OPR = AVR]

3.2.2.24 The FAA establishes performance criteria for Explosives Detection Systems (EDS) to allow manufacturers to develop EDS for FAA testing and certification, and possibly deploy higher threat operations (primarily international flights). [OPR = ACS]

3.2.2.25 The FAA purchases and deploys enhanced x-ray devices and explosives vapor/particle detectors suitable for screening electronic items to conduct operational testing and collect data for possible use in future rulemaking efforts. [OPR = ACS]

3.2.2.26 The introduction of very large aircraft requires airport design research, with emphasis on pavement design, which continues during this timeframe. [OPR = ARP]

3.3 SAFETY AND POLICY

3.3.1 Safety and Compliance

3.3.1.1 The Aviation Rulemaking Advisory Committee (ARAC) continues to be used for recommending rulemaking and policy actions to the agency. [OPR = AVR]

3.3.1.2 The FAA continues to develop safety standards, which are published for public comment. [OPR = AVR]

3.3.1.3 The FAA develops new voluntary compliance programs to be used in lieu of civil penalties and suspensions. These include internal evaluation, self disclosure, and remedial training techniques. [OPR = AVR]

3.3.1.4 The FAA expands its commitment to a joint government/industry safety planning agenda. [OPR = ASF]

3.3.1.5 The General Aviation Action Plan is expanded to an agency-level plan and is coordinated within FAA and industry. [OPR = AVR]

3.3.1.6 The FAA actively participates in the development of the ICAO Strategic Plan seeking a more responsive and effective organization for the 21st century. [OPR = API]

3.3.1.7 The FAA continues an aggressive analysis and evaluation of human protection and survivability in civil aviation. [OPR = AVS]

[OPR = AVR]

3.3.2.3 The government/industry general aviation partnership defrays the development costs of new aircraft products and reduce certification time, thereby making the product more affordable to the public and more competitive with foreign markets. [OPR = AVR]

3.3.2.4 New aircraft certification standards implemented to accommodate a new generation of general aviation aircraft in the transport and personal use categories. These new certification standards place less of an economic burden on manufacturers, thereby reducing the amount of development costs normally passed on to the customer. [OPR = AVR]

3.3.2.5 The FAA takes actions to promote international coordination and harmonization of aircraft certification. [OPR = AVR]

3.3.2.6 Bilateral and multilateral agreements with foreign civil aviation authorities are established or modified to develop more effective international working agreements and clearer international safety philosophies. [OPR = API]

3.3.2.7 The capabilities of other foreign regulatory authorities are accepted when sufficient expertise and comparable standards are providing equivalent levels of safety. These agreements conserve surveillance resources by allowing FAA to accept foreign approvals or certifications. [OPR = AVR]

3.3.2.8 Similar levels of security are established for passengers on foreign carriers operating to the U.S. [OPR = ACS]

3.3.2.9 The FAA negotiates security improvements with selected foreign carriers to provide for better coordination and application of aviation security procedures overseas, and comply with P.L. 101-604 to ensure a similar level of protection for U.S. travelers. [OPR = ACS]

3.3.2.10 The FAA coordinates the modernization of its ATM system, including the use of satellite-based systems with interested countries at an international conference. [OPR = ASD]

3.3.2.11 The FAA fosters international relations, by promoting the development of a global ATC system which utilizes compatible procedures and harmonized equipment. [OPR = API]

3.3.2.12 The FAA takes the lead in the international coordination and harmonization of aircraft certification and regulatory requirements. This ensures more uniform application of rules overseas and reduces instances of noncompliance at home and abroad. [OPR = AVR]

3.3.2.13 The FAA establishes and applies new or modified certification standards and practices which reduce economic burdens on applicants while maintaining appropriate safety standards for the class of aircraft being certified. [OPR = AVR] agencies), to convince the State Department to accept additional essential FAA personnel overseas. [OPR = API]

3.3.2.16 The FAA continues the deployment of civil aviation security liaison officers and security inspectors overseas, as needed, and evaluates the results to improve coordination, technical advice, and the timeliness of security inspections and assessments. [OPR = ACS]

3.3.2.17 The FAA ensures the development and deployment of advanced security technology, especially for explosives detection, and ensures that regulatory standards are consistent. [OPR = ACS]

3.3.2.18 The FAA encourages the improvement of ICAO Standards and Recommended Practices for the screening of passengers, cargo, and mail as well as more efficient/effective security measures and access controls for restricted areas. [OPR = ACS]

3.3.2.19 Legislative Proposals. The FAA works with the departments of Commerce and Treasury to develop a plan to provide economic incentives to the U.S. aviation industry. The plan is designed to: [OPR = API]

- Promote aviation R&D
- Provide incentives for the purchase of general aviation aircraft
- Facilitate cooperative agreements designed to provide technical knowledge and capabilities to U.S. aviation industries
- Seek authority to provide training and technical assistance to foreign authorities without reimbursement.

3.3.2.20 The FAA supports actions to reduce product liability and make it possible and profitable to manufacture personal use general aviation aircraft in the United States. [OPR = API]

3.3.2.21 The FAA provides leadership in the worldwide adoption of CNS/ATM. [OPR = API]

3.3.2.22 The FAA works through ICAO to pursue effective international standards. [OPR = API]

3.3.3 Environmental Compatibility

3.3.3.1 The FAA continues joint FAA/NASA research to develop technologies which decrease aircraft noise and emissions of nitrogen oxides, carbon monoxides, and hydrocarbon emissions. These programs provide the basis for new certification standards for aircraft in the 21st century. [OPR = API]

3.3.3.2 The FAA develops regional and service organization networks to consider the environmental impacts of all agency decisions. Improved training, adequate resources, and improved technical assistance results in timely consideration of the environmental impact of agency decisions resulting in more efficient decisionmaking. [OPR = API]

3.3.3.3 The FAA identifies and continues the clean up of FAA hazardous waste sites to bring these sites into conformity with existing laws, and begin comprehensive surveys of all FAA sites for environmental compliance. [OPR = API]

3.4.1 People

3.4.1.1 The FAA continues to emphasize a more open, collaborative culture. The relationship between managers and employees is more interactive. [OPR = AHR]

3.4.1.2 The FAA ensures that human resource planning occurs concurrently with new system design and development. [OPR = AHR]

3.4.1.3 The agency continues its cultural change towards: [OPR = AHR]

- Diversity - employee training, action planning, recruitment
- Executive, managerial, and supervisory training/development emphasizing strategic planning, cross functionalism, collaborative work strategies, managing diversity
- A collaborative labor relations program
  - Expanding efforts to create a more cooperative relationship with labor unions through programs such as Employee Involvement (EI) in AF and Quality Through Partnership (QTP) in AT
- Employee survey and feedback for continuous improvement and involvement of employees in decisions which affect them.

3.4.1.4 The FAA develops a more flexible personnel system to meet changing staffing requirements and makes better use of existing flexibilities (e.g., retention allowance, recruitment bonus). The agency initiates demonstration projects to study new compensation programs, new performance management systems, and a new self-managed team concept. [OPR = AHR]

3.4.1.5 The FAA provides more flexibility in when and where we do our work through continued use of flexible work schedules and a demonstration/study of flexiplace work policy. [OPR = AHR]

3.4.1.6 The FAA implements a technical training system based on true training needs; i.e., all required training will be identified and funded. [OPR = AHR]

3.4.2 Financial Management

3.4.2.1 The FAA re-evaluates the necessity of new and existing regulations, consistent with safety or other statutory requirements, to reduce the economic regulatory burden on industry. [OPR = AVR]

3.4.2.2 The FAA revises its planning processes to ensure that the agency budget and its associated plans (e.g., CIP, R&D) reflect and support the FAA Operational Concept. [OPR = API]

3.4.2.3 The FAA develops alternatives for operations funds budget submissions (such as "activity-based," "zero-based," "performance-based," etc.). [OPR = ABU]

3.4.2.7 The FAA examines merits of making the AIP block grant program available to states; as well as provide AIP to privately-owned, non-reliever airports. [OPR = ARP]

3.4.3 Leadership, Management, and Organization

3.4.3.1 The FAA continues to be progressive and innovative to ensure it moves towards a value system that honors service, quality, teamwork and respects the dignity and worth of the individual. [OPR = AHR]

3.4.3.2 The operational planning "process" continues to be institutionalized within the FAA. [OPR = AXO]

- In what domestic airspace will Mode S/datalink be required?
  - What specific information (weather, air traffic, etc.) should be datalinked?
  - What should be the balance between digital and analog communications between ground and air craft?
  - Should TCAS be used for aircraft separation?
- The FAA must decide on adopting a new federal position on airport development by creating a national Airport Strategic Plan.
- Should the FAA join into partnerships with other U.S. Government entities and/or private corporations to increase the competitiveness of U.S. aviation interests?
- Should the FAA support a national industrial policy to provide economic incentives for he aviation industry?
- Should the FAA promote the notion of examining the feasibility of a world or regional aviation authority?

4.1 AIR CARRIER, GENERAL AVIATION, AND DOD OPERATIONS

4.1.1 Air Traffic Management

4.1.1.1 All aircraft are allowed to navigate from point to point at or above FL180 without regard to fixed routes or ground based Navigation Aids (NAVAIDs) during the en route phase of flight. [OPR = AAT]

4.1.1.2 Aeronautical Telecommunications Network (ATN) and data link are the primary communications vehicles between controller and pilot for the transmission of weather information, however, those not data link equipped are accommodated through voice communication capability. [OPR = AAF]

4.1.1.3 ATN and data link are the primary communications vehicles between controller and pilot for the transmission of routine control instructions, however, those not data link equipped are accommodated through voice communication capability. [OPR = AAT]

4.1 1 4 Data link is being tested between aircraft for the purpose of developing participatory separation procedures. [OPR = AAT]

4.1.1.5 Next Generation Radar (NEXRAD) and the radar weather processor provide real-time hazardous weather depiction to the air traffic airspace manager. [OPR = AAT]

4.1.1.6 Weather products, supplemented by automatic transmission of atmospheric conditions from the airborne fleet, such as airport and regional weather products and winds aloft, are developed and displayed in easy to understand graphics. [OPR = AVR]

4.1.1.9 Most information needed for the planning and managing of flight activities is stored in centralized data bases accessible by all aircraft operators and air traffic managers. [OPR = AAT]

4.1.1.10 R&D evolves from the current Enhanced Traffic Management System (ETMS) to the Traffic Management Processor (TMP) of tomorrow. [OPR = ASD]

4.1.1.11 Airport and airspace efficiency is increased through the introduction of computer generated control instructions that maximize the arrival flow for each and every air traffic situation in real time. [OPR = AAT]

4.1.1.12 A consortium of FAA, aviation industry, and other groups accelerate the overall implementation of a satellite system for Communication, Navigation, and Surveillance (CNS). The consortium: [OPR = ASD]

- Develops avionics that serve multiple purposes in one component such as navigation and surveillance from GNSS and ADS technology. This type of multiple-purpose avionics ensures access to all, and lowers aggregate costs of navigation, surveillance and communications equipment in each aircraft.
- Provides a forum for consensus of all users concerning early implementation.
- Accelerates the early decommissioning of ground-based systems such as Very High Frequency Omnidirectional Radio Range (VOR), Distance Measuring Equipment (DME), long range radar, etc.
- Creates a procurement process (similar to ATN) to speed up the procurement cycle.

4.1.1.13 ADS data link and satellite voice communications are the primary means of surveillance and communications in the oceanic environment, fostering increased capacity and more fuel and time-efficient flight profiles. [OPR = AAT]

4.1.2 Quality Assurance

4.1.2.1 The full development and acceptance of a safety performance analysis system is underway within several organizations of the agency which allows for dynamic targeting of inspection and surveillance activities from a risk assessment perspective. [OPR = AVR]

4.1.2.2 R&D of statistically based risk assessment programs is underway in all agency inspection and surveillance programs. [OPR = AVR]

4.1.2.3 Inspection support and the gathering of inspection data (such as safety and security inspections) is conducted utilizing personal pen based computer technology. These personal support systems also provide regulatory support information needed by the individual in carrying out the specific task. [OPR = AVR]

4.1.2.4 Oversight of the accuracy and quality of the navigational, communications, and surveillance systems will begin to evolve into a joint FAA/user cooperative venture in the en route environment. The user fleet will be able to look for and more directly report on observed deviations. These deviations are confirmed/corrected by the FAA by means other than the Semi-Automatic Flight Inspection (SAFI) national grid system. The FAA retains all responsibilities for terminal operation evaluation. Also, procedures development/confirmation is accomplished in a

- Aircraft/NAS integration
- GPS approach input and display criteria
- Maintenance system error reduction
- Technician interfaces with highly automated test and checkout equipment
- Automated exchange of technical information
- Controller transition to automated systems
- Analysis of controller/team job performance.

4.1.3.2 The FAA initiates human factors studies for CAT III equivalent GPS approaches. [OPR = AVR]

4.1.3.3 Through the use of published certification criteria, the FAA reduces the routine dependence on human vigilance for the detection of complex weapons or explosive devices. These detection systems improve the efficiency and effectiveness of security screening systems as well as facilitate the movement of passengers, crew, and cargo through airports. [OPR = ACS]

4.2 NATIONAL AIRSPACE SYSTEM INFRASTRUCTURE

4.2.1 System Support

4.2.1.1 Satellite-based navigation is the primary source for departure, en route and approach guidance allowing the decommissioning of many Non-Directional Beacon (NDB), Instrument Landing System (ILS), VOR/DME, Localizer Directional Aid (LDA), Simplified Directional Finding (SDF), and VHF Direction Finding (DF) navigation and approach aids. All operators will have instrument approach capability to hundreds of additional airports. [OPR = AVR]

4.2.1.2 To varying degrees, ground-based navigation, landing and surveillance systems are augmented by space-based systems. [OPR = AAF]

4.2.1.3 The NAS infrastructure is composed of both government-owned and some leased equipment and services. [OPR = AAF]

4.2.1.4 New systems are more intelligent, providing failure prediction, artificial intelligence, expert systems, etc. [OPR = AAF]

4.2.1.5 The NAS infrastructure is operated and managed through area operations control centers and a national operations control center (collocated with the Air Traffic Control System Command Center (ATCSCC). [OPR = AAF]

4.2.1.6 Some intrafacility/interfacility communications are transmitted via fiber optic and satellite transmission systems. [OPR = AAF]

4.2.1.7 A new cost and performance data system is provided incorporating cost to provide services to customers, overall cost of operating the system, trend analysis, and facility performance related data. [OPR = AIT] airport's role and forecast activity level, and identify development needed to maintain safety and provide adequate capacity. The plan describes system requirements, and provides the general type and scale of development projects needed to meet national goals. [OPR = ARP]

4.2.2.2 A consensus based planning process, including the users, airport operators, and planning organizations, is used to determine which developments should receive federal grant money. [OPR = ARP]

4.2.2.3 The FAA proposes statutory modifications to the airport grant-in-aid program giving the agency authority to direct federal funding more cost effectively. [OPR = ARP]

4.2.2.4 The FAA provides guidelines and financial aid for land use planning and noise mitigation measures at airports. The transition to quieter Stage 3 aircraft makes compatible land use easier to achieve because a much smaller area of land is affected. [OPR = ARP]

4.2.2.5 The FAA continues to assist the ongoing conversion of military airfields by providing airfield improvement financial support, approach aids, and operating subsidies until the civil operation becomes financially self-sustaining. ATC services are provided consistent within existing policies. [OPR = ARP]

4.2.2.6 The FAA prudently applies the AIP's letter-of-intent mechanism to induce airport capacity development. [OPR = ARP]

4.2.2.7 The agency implements standards, in coordination with all affected parties, for universally accepted ID/access media. [OPR = ACS]

4.2.2.8 The FAA performs positive passenger/bag match without causing serious operational difficulties. [OPR = ACS]

4.2.2.9 The FAA develops hardening standards for specified equipment as a means of preventing catastrophic damage resulting from criminal acts against civil aviation. [OPR = ACS]

4.2.2.10 The FAA requires the screening of carry-on and checked baggage at selected locations using certified explosives detection systems, x-rays, or other detectors. [OPR = ACS]

4.2.2.11 The FAA shifts more planning and financial resources to terminal building and access projects to achieve airport efficiency as well as capacity objectives. [OPR = ARP]

4.2.2.12 The FAA completes implementation of the recommendations of the report to Congress, Long-Term Availability of Adequate Airport System Capacity. [OPR = ARP]

4.2.2.13 Improved operations on parallel runways separated by less than 2,500 feet enhances capacity by reducing the separation required for independent arrival and departure operations. [OPR = ASC]

4.2.2.14 Independent and dependent parallel approaches allow approaches to triple parallel runways when the runway centerline spacings do not meet the standard for fully independent operations. [OPR = ASC]

4.3.1 Safety and Compliance

4.3.1.1 Industry and foreign governments have input into most agency regulatory and safety policy information. [OPR = AVR]

4.3.1.2 The FAA system of rulemaking through broad consensus building is a world model. [OPR = AVR]

4.3.1.3 Voluntary compliance programs expand throughout the agency and successfully promote compliance with agency safety standards. [OPR = AVR]

4.3.1.4 Joint safety agendas are developed on an annual basis with industry groups as well as foreign civil aviation authorities. [OPR = AVR]

4.3.1.5 The FAA continues to provide international leadership within ICAO for the purposes of promoting a safe and efficient world aviation system. [OPR = API]

4.3.2 Global Leadership

4.3.2.1 FAA and foreign civil aviation authorities share safety data. [OPR = AVR]

4.3.2.2 FAA continues to lead in the international harmonization of aeronautical product certification, thereby reducing or eliminating manufacturer costs for "revalidation" of designs. [OPR = AVR]

4.3.2.3 FAA continues to aggressively market its managerial, technical, and regulatory expertise. [OPR = API]

4.3.2.4 The FAA looks for new technical, financial, and management methods to support foreign countries in the development and operation of their aviation infrastructures. [OPR = API]

4.3.2.5 The FAA examines the feasibility of a single international ATM system to provide a more seamless ATC system. [OPR = AAT]

4.3.2.6 The FAA explores the feasibility of harmonized, internationally recognized standards and practices for aircraft, airmen, airport, and commercial operations. [OPR = AVR]

4.3.2.7 Legislative Proposals. The FAA continues to support passage of legislation which provides tax incentives designed to promote aviation R&D, reduces product liability costs, provides incentives for purchase of general aviation aircraft, and facilitates cooperative agreements which provide technical knowledge to U.S. aviation industries. [OPR = API]

4.3.2.8 The FAA continues to provide international leadership in the planning and implementation of a worldwide network of (CNS) ATM systems. [OPR = API]

4.3.3.3 New techniques allow agency personnel to quickly assess environmental impacts of alternatives early in analysis, thereby speeding agency decisions. [OPR = API]

4.3.3.4 The harmonization of U.S. and international environmental standards saves the aviation industry money by eliminating duplicate regulation and certification. [OPR = API]

4.3.3.5 Consensus building between FAA and private sector groups promotes compatible airport land use. [OPR = ARP]

4.3.3.6 The FAA effectively uses the AIP airports to comply with more stringent requirements under the Clean Air Act and Clean Water Act, while preserving airport operational and safety integrity. [OPR = ARP]

4.4 RESOURCE MANAGEMENT

4.4.1 People

4.4.1.1 Alternative personnel systems are in place to address recruitment, retention and performance management issues. Staffing flexibilities allow the agency to address changing external and internal demands. Demonstration projects are in place to study the effectiveness of self-managed teams, seasonal hiring, new compensation programs, and performance appraisal systems that reward teamwork. [OPR = AHR]

4.4.1.2 There are no significant net increases in FAA staffing as demand for services increase, and the agency capitalizes on efficiencies gained from new technology. [OPR = AHR]

4.4.1.3 The size and composition of the FAA workforce has changed. For example: [OPR = AHR]

- Within AF, the mix of work now requires less highly specialized maintenance skills; however, a percentage of skilled technicians are dispatched from sector offices/other centrally located duty stations to perform corrective and preventive maintenance.
- There is an increased requirement for individuals with software maintenance skills.
- Some downsizing in AF occurs as FAA moves to a satellite-based system.
- As the workforce matures beyond entry level, career development through work assignments and advanced training is encouraged. FAA has developed succession plans to create an applicant supply source for key managerial positions.

4.4.1.4 Training now capitalizes on education/skills people receive before they are hired by the FAA. [OPR = AHR]

4.4.1.5 Training delivery that makes use of distance learning technology is in place. [OPR = AHR]

4.4.1.6 The FAA Academy is a tuition-based institution which provides low-cost, current technical training. [OPR = AAC]

4.4.2.4 FAA/DOT explores new methods of funding sources for capitalizing operation of satellite applications. [OPR = API]

4.4.3 Leadership, Management, and Organization

4.4.3.1 Organizational structures are flexible and adaptable to the changing aviation environment as well as customers' needs. To meet this dynamic, complex environment, the FAA moves away from its current structure. The FAA builds upon its strengths and maintains an open, receptive attitude toward new management strategies for the future. Fewer levels of supervision exist. Responsibility and accountability are closer to the actual operation allowing the concurrent ability to respond quickly to customer needs. The field structure is streamlined to provide key support to operating elements. [OPR = API]

4.4.3.2 Formal integrated planning mechanisms are in place which include industry participation. [OPR = API]

4.4.3.3 Continuous organization evaluation methods are in place (involving customers). [OPR = AXQ]

5.1.1 Air Traffic Management

5.1.1.1 Air traffic management is based upon an open communications network which allows service providers and system users to share the same information on flight plan and control activities. [OPR = AAT]

5.1.1.2 Sophisticated collision avoidance systems allow pilots to assume additional responsibilities for separation between aircraft and ground obstacles. [OPR = AVR]

5.1.1.3 System Failures: Catastrophic failure of the air traffic system service will not occur. (See Systems Support section). [OPR = AAF]

5.1.1.4 System planning of daily operations is routinely shared between users and ATC through interactive computer connections and instantaneous negotiations. ATM computers and flight deck avionics share information via data link without direct controller or pilot intervention. [OPR = AAT]

5.1.1.5 To increase capacity, under certain circumstances, the FAA uses time-based aircraft separation procedures, to provide greater efficiencies than distance-based separation standards (e.g., successive arrivals at the runway threshold). [OPR = AAT]

5.1.1.6 With the advent of total satellite-based surveillance and communications, the oceanic domain becomes an extension of the domestic en route ATM system. [OPR = AAT]

5.1.1.7 The system accommodates all aircraft types and operations (including Visual Flight Rules (VFR)) which are fully integrated into the NAS now that all aircraft are electronically identifiable. [OPR = AAT]

5.1.2 Quality Assurance

5.1.2.1 International interconnectivity allows for multiple civil aviation authorities to access government and industry data. [OPR = AIT]

5.1.2.2 Individual reviews are conducted following sophisticated analyses which target specific areas for technical quality assurance. [OPR = AVR]

5.1.2.3 As GPS assumes the major navigation role, the FAA likewise transitions the terminal operation evaluation to a shared FAA/user community process. By the time all current facilities are phased out, the FAA flight inspection function is a limited sampling reported confirmation/corrections, procedure checks and balances, accident investigation flight checks, and new facility commissioning support. [OPR = AVS]

5.1.3 Operational Human Factors

5.1.3.1 Implementation of previous study recommendations is completed. [OPR = AXD-4]

5.1.3.2 Integration of 2nd generation automated flight decks is ongoing. [OPR = AVR] government-owned and leased equipment and services. [OPR = AAF]

5.2.1.2 The remaining ground-based landing and surveillance systems are centered in the terminal environment. Some radar facilities located along national boundaries remain. [OPR = AAF]

5.2.1.3 The AF organizational structure is life-cycle management-based around major service areas. [OPR = AAF]

5.2.1.4 The AF technical workforce comprises system generalists and system specialists (i.e., System Managers/System Analysts). [OPR = AAF]

5.2.1.5 Operations control center system managers have responsibility for the operational integrity of all fielded systems and direct the activities of both FAA and support personnel. [OPR = AAF]

5.2.1.6 Navigation is provided by GNSS with the remaining ground-based landing and surveillance systems centered primarily in the terminal environment. Most ground-based navigational aids, radar sensors, remote transmitter/receiver sites have been decommissioned. [OPR = AAF]

5.2.1.7 Workforce size is influenced by the pace and extent of satellite applications and the resultant displacement of today's ground-based CNS facilities. [OPR = AXO]

5.2.1.8 Communications between aircraft and ground control are 75 percent digital data and 25 percent analog. [OPR = AAF]

5.2.1.9 Automated databases provide archival and decision-making support for major internal security programs as part of FAA's contribution towards national standardized security structure for all federal agencies. [OPR = ACS]

5.2.1.10 Evaluate and improve the integrated security management system for the protection of FAA facilities and personnel. [OPR = ACS]

5.2.2 Landside/Airside Operations

5.2.2.1 The FAA adjusts and improves a universally accepted ID/access media system. [OPR = ACS]

5.2.2.2 The FAA evaluates the impact of mid-term countermeasures on the aviation operating environment. [OPR = ACS]

5.2.2.3 The FAA continues R&D to cope with new security threats and improve existing counter measures. [OPR = ACS]

5.2.2.4 Air carriers inspect all carry-on and checked baggage with certified explosives detection systems. [OPR = ACS]

5.2.2.9 The FAA influences, coordinates, and provides leadership to develop an integrated transportation system. [OPR = API]

5.2.2.10 The FAA provides leadership to ensure coordinated airport system development among Federal, state, and local governments. [OPR = ARP]

5.2.2.11 To fully address the issue of airport capacity, the FAA needs to analyze the gap between demand at the busiest airports and projected capacity. The analysis should include a "most likely" planning scenario and a recommended set of actions to deal with the demand/capacity gap. It also needs to discuss a range of alternative scenarios and the FAA's response to each. [OPR = ARP]

5.3 SAFETY AND POLICY

5.3.1 Safety and Compliance

5.3.1.1 The agency is informed of pending inter-agency or foreign regulatory policy conflicts through extensive computer networks. [OPR = AVR]

5.3.1.2 Rulemaking policy costs and benefits are more easily computed and compared to avoid duplication and unnecessary regulatory burdens. [OPR = AVR]

5.3.1.3 The participatory approach to the development of regulatory and agency policy expands significantly due to public access and rapid dissemination of information around the globe. [OPR = AVR]

5.3.1.4 Public access to policy makers through electronic media promotes compliance and partnership between government and private industry. [OPR = AVR]

5.3.2 Global Leadership

5.3.2.1 Objectives of the FAA "Vision for the Year 2010" are realized when an international network of qualified aviation authorities is recognized and allowed to perform certification, inspection, and surveillance activities for ICAO member states. [OPR = API]

5.3.2.2 FAA institutionalizes an agencywide strategy for sharing knowledge, technology advancements, and education initiatives with other organizations and industry. [OPR = AXO]

5.3.2.3 A single international ATM system is in place. [OPR = AAT]

5.3.2.4 A seamless international ATC system is in place. [OPR = AAT] financial, and management support for the planning and operation of aviation safety infrastructure systems worldwide. [OPR = API]

5.3.3 Environmental Compatibility

5.3.3.1 A new generation of environmentally friendly aircraft enter the fleet. [OPR = API]

5.3.3.2 Compatible international environmental standards are achieved. [OPR = API]

5.3.2.3 FAA becomes more effective and sophisticated in reducing the adverse environmental impacts of its actions. [OPR = API]

5.3.2.4 The FAA integrates the environmental evaluation of airport development with other modes of transportation to facilitate multi-modal projects and reasoned choices among modes. [OPR = ARP]

5.4 RESOURCE MANAGEMENT

5.4.1 People

The role of the operational workforce has changed. For example:

5.4.1.1 The air traffic controller is a system manager as computers provide more information to users without controller intervention. [OPR = AAT]

5.4.1.2 The size of the AF workforce is influenced by the pace of application of satellite-based systems. [OPR = AAF]

5.4.1.3 Contingency plans deal with the turnover associated with a mature work force, placing emphasis on cultural diversity and job complexities. [OPR = AHR]

5.4.1.4 Through the use of innovative concepts and methods, the training system is able to keep pace with operational requirements calling for employees with new knowledge, skills, and abilities. [OPR = AHR]

5.4.2 Financial Management

5.4.2.1 The FAA examines alternatives to the present method of financing the aviation trust fund. [OPR = API]

5.4.3 Leadership, Management, and Organization

5.4.3.1 FAA formal planning processes include participation from key international aviation groups. [OPR = API]

5.4.3.2 The FAA continues to focus on pushing the vision beyond the horizon, as part of an operational planning process designed to effectively meet future requirements. [OPR = AXO]

To capture some of aviation's allure, we invite you to ride "jump seat" in the cockpit of a commercial carrier on a typical flight from Dallas/Fort Worth International Airport (KDFW) to Tokyo. This fictitious trip highlights the interconnectivity of NAS components from the perspective of those who fly in the system and those at the FAA who operate it.

It should be recognized, however, that this is but one example of myriad types of flights which are served each day by FAA within the NAS. A General Aviation flight from Minneapolis to Moline, a helicopter flight from an outlying area to the airport, cropduster activity in agricultural areas, an emergency medical evacuation flight, a lost student pilot on his first solo flight and many other types of flights, while having some commonality, will require use of a variety of airborne and ground-based equipment and services according to aircraft capabilities, pilot training and airspace requirements pertaining to the particular operation.

Indeed, providing an air traffic management system -- which in addition to operating it includes developing, modernizing and maintaining it -- is only one of at least three broad "lines" of FAA business. FAA also regulates and oversees aviation users and assists in the development of the U.S. airport infrastructure.

Woven into this Texas/Tokyo operational scenario are references to selected FAA programs and projects--their status today and their anticipated impact on the system over the next two years. At the end of the flight script, we'll fast forward to the year 2000 to see how the system has changed by century's end.

Our flight would have been seriously delayed, if not permanently grounded, had this scenario featured every line item in the budget. Those programs and new technologies singled out for inclusion are scheduled to add important new capabilities to the NAS--capabilities expected to yield a significant return on investment for the FAA and the airlines. New technology offers air carriers opportunities to maximize operating efficiencies, leaving them with more discretionary income to invest in equipment upgrades, maintenance and new technology, starting the cycle over.

The United States lays claim to the finest air transportation system in the world. It is also the busiest and most complex, owing to a mixture of equipment, techniques and skills. At its heart is a vast network of ATC, navigation, surveillance and communication equipment that has been in a constant state of evolution for over 40 years.

On the same day as our flight, the FAA will handle over 200,000 takeoffs and landings from the nation's 17,600 airports. It will perform 800 safety inspections, 82 security inspections, 14 safety seminars and countless maintenance and monitoring functions on more than 40,000 FAA facilities and system installations. Much of the FAA job is behind-the-scenes activity...never visible to the flying public....transparent to the system user.

communication equipment navigation and landing systems and flight data processors, so that ATC can fulfill its mission. A nationwide network of Maintenance Control Centers (MCCs) monitors the ATC infrastructure 24 hours a day, dispatching technicians to perform preventive and corrective maintenance on a moment's notice.

Tests are repeatedly run on all major systems to ensure they are functioning within tolerance. System redundancy is checked and rechecked. The life expectancy of older-generation equipment must be extended through continual repair, until new systems come on line.

An often unrecognized cost of technological innovation is the expense of maintaining the old system, while it's being replaced by a new one. Unlike other organizations, the FAA can never close shop, even for a second, while this metamorphosis occurs. This double requirement of keeping both systems up and running during the transition period is a constant drain on resources.
With each annual budget submission, this scenario will be modified as progress, time and technology sharpen our vision of the future. Each budget item, including those not featured in this section, represents an incremental step toward an ever-evolving future system; each step not taken is a delay along the path to that future.

A Flight through Today's National Airspace System

In the Beginning

Long before the airplane you are about to board was put into service carrying passengers, its design and manufacture was closely scrutinized by the FAA to ensure that it is safe and meets the latest safety standards. Early in its development, the manufacturer applied to the FAA for approval of the design. This started an extensive involvement by the FAA throughout the airplane's development and manufacture. FAA aviation safety engineers and designees reviewed extensive data and witnessed tests to determine that all aspects of the design including structures, systems, propulsion, and flight characteristics and performance meet the appropriate safety requirements. When the first examples were built, FAA test pilots and engineers conducted flight tests and any necessary design changes were made before the design approved and a Type Certificate issues.

FAA inspectors were intensely involved in the manufacturing process to ensure the manufacturers production and quality system made the aircraft to the FAA approved design and that it was in a condition for safe operation.

FAA responsibility does not end there. It continues throughout the life of the aircraft. If modifications to the airplane's design are made, the FAA will review the modification and certify that they meet the applicable safety standard. If safety related problems occur in service, the FAA will take prompt corrective action. This ensures the airworthiness of the aircraft you are about to board as it continues in service.

Preflight Activities

Prior to the mid-morning departure of TransGlobal Airlines Flight 987 (TGA987) from the KDFW, the Captain obtains a briefing from the airline dispatcher in charge of authorizing the flight. TGA987, a through flight to Tokyo with a stop in San Francisco, is scheduled to depart at 9:31, arriving at San Francisco International Airport (KSFO) at 11:17.

of usable arrival runways from 2 to 1. Later, airline dispatch offices, including TGA's, were alerted that a flow initiative (one of several nationwide) had been invoked at KSFO, decreasing the hourly ATC acceptance rate from 55 to 33 aircraft.

The dispatcher discusses this situation with the TGA pilot during the preflight briefing and apprises him of weather and winds aloft along the intended route of flight, as well as pertinent information, such as runway closures and changes in the status of NAVAIDs and landing systems.

ATC requires flight plans for Instrument Flight Rules (IFR) operations to be filed at least 30 minutes prior to a flight to allow the ATC system time to validate the plan, provide it to appropriate ATC facilities, and formulate a departure clearance. The TGA dispatcher meets this deadline, and the flight plan data are routed through a communication network to Fort Worth Center's Host computer.

The Host computer generates a flight plan for TGA987, automatically assigning it a Controlled Departure Time (CDT) of 10:03 a.m. Because of the traffic management initiative at KSFO, ATC places our flight on "gate hold."

The Departure Clearance Process

Prior to engine start, the flight crew requests and receives a Predeparture Clearance (PDC) from ATC, confirming TGA987's route of flight, altitude data and transponder code assignment. KDFW is one of only 30 airports in the system where no voice communications are necessary to accomplish this.

A Very High Frequency (VHF) data link in the cockpit enables this information to be electronically transmitted in seconds over a digital channel to Aeronautical Radio Incorporated (ARINC), an airline industry-owned and operated aeronautical communications company. ARINC acts as a middleman, relaying departure clearance data between the Host computer and the cockpit. Messages are received on a screen in the cockpit and can be backed up by hard copy. The elimination of voice communications in this phase of the flight has dramatically reduced radio frequency congestion, reduced the potential for clearance error, and cut the time aircraft without data link must spend awaiting instructions, advisories, and clearances from the tower. PDC has also lessened the clearance delivery controllers' workload by 80 percent.

PDC is the first application of data link technology in the civil ATC system. By 1995, about 60 airports will be PDC-equipped, enabling the large percentage of the commercial fleet, which are already data link capable, to benefit from this automated procedure.

Surface Movement (Departure Phase)

As the CDT for TGA987 nears, ATC advises the captain of engine start time. The aircraft pushes back from the gate and proceeds to the common movement area. The Captain then requests a clearance to taxi from ATC.

Ground controllers also utilize flight progress strips, which show that part of the flight plan relevant to the KDFW tower. These strips are automatically printed at all ATC facilities handling a particular flight.

TGA987 is cleared to taxi, and the pilot is advised of other traffic in the immediate area. The tower directs our

to accommodate even higher air traffic levels at KDFW.

In addition to two new control towers, a total of four ASR-9 terminal radars are scheduled for deployment here by 1995. This latest-generation ASR continuously detects and displays, with a moving target indicator, all aircraft within a 60-nautical mile range. It combines redundant solid-state electronic components with a remote maintenance monitoring capability to ensure an availability of 99.98 percent, or less than 4 hours of down time per year.

Before the end of this year, Mode Select (Mode S) ground sensors will be installed here and at other high-density aircraft environments around the country to improve surveillance. Mode S ground stations determine an aircraft's position by interrogating its transponder--onboard avionics which reply with the aircraft's identity and altitude. Mode S ground stations will also furnish an all important digital data link directly to the cockpit of properly equipped aircraft, which will be employed to provide a number of services to the pilot.

In addition, KDFW will have Terminal Doppler Weather Radar (TDWR) by mid-1994--one of 45 airports scheduled to receive the current windshear detection equipment. This pencil-beam radar pinpoints the location and intensity of hazardous weather, such as microbursts and gust fronts, and feeds that information to terminal radar approach and tower controllers.

Current-generation radars cannot peer inside thunderstorms and measure wind velocities, as TDWR can, using the doppler principle: frequencies from approaching objects are higher, those from receding objects are lower. Severe weather is no stranger to Dallas and TDWR will enhance the controllers' capability to keep flights clear.

But today the air is calm, as the TGA flight lifts off the runway and proceeds according to clearance. ATC responsibility is transferred--or "handed-off"--to a departure controller at the Terminal Radar Approach Control (TRACON) facility, located underneath the control tower cab. A data block representing TGA987 appears on the controllers' radar screen.

The TRACON, too, uses the ARTS to integrate ASR and secondary radar surveillance data with flight plan data received from the en route facility. Aeronautical information and weather updates are automatically distributed throughout the TRACON.

Onboard the 747-400 aircraft much more data and additional automation is available to the TGA pilot. Prior to takeoff, route information, aeronautical charts and airport layouts were pre-loaded by airline computers into the database of the aircraft's Flight Management System (FMS). FMS computers are able to determine and adhere to a 4-dimensional flight profile, with only occasional assistance of ground-based NAVAIDs. With the introduction of the Global Navigation Satellite System (GNSS), these capabilities will be even further refined.

The FMS can also access wind and temperature information to optimize the 4 dimension profile and calculate correct data for clearance negotiations. This information can be downlinked to airline flight operations, as trials during 1993 and 1994 are now proving, to provide real-time (as it is happening) en route weather information to the next flight passing along the same route.

As TGA987 leaves airspace controlled by the TRACON, the aircraft is handed off to an en route controller at Ft. Worth Center, the first of several en route ATC facilities that will handle our flight before touchdown at KSFO.

TGA987's progress is monitored by a controller using a radar track and associated data block on the radar display.

Handoffs are made in advance of each boundary crossing--sector or center. The cockpit crew is always advised by the controller of the next radio frequency on which to announce the aircraft call sign and altitude. While the airline dispatcher can exchange information with the cockpit by data link, ATC is limited to voice communications with the pilot.

The cruise segment of the flight continues until the flight profile calls for descent to begin. The transition from sector to sector during the descent is handled in the same fashion as the climb phase. The crew follows ATC instructions, stepping down through altitudes, before being queued into landing order by a team of controllers in the Bay TRACON, located in Oakland, who makes sequencing decisions for KSFO based on local conditions and parameters.

Soon these decisions will be automated by a new system, known as the Center TRACON Automation System (CTAS), which uses a data base of aircraft performance, radar, and flight plan information to smooth the flow of air traffic into an airport. A CTAS prototype is now being evaluated at Stapleton Airport in Denver. In 1994, limited deployment of certain CTAS software components will begin at 10 airports and selected centers nationwide.

For now, TGA987 must slow its descent per ATC instructions to maintain adequate airborne spacing. Suddenly, the cockpit is filled with a computerized voice, advising the pilot of "traffic, traffic." Our pilot checks the cockpit's TCAS II display for the position of the intruding aircraft relative to TGA987. This display assists the pilot in visually acquiring the plane responsible for activating the alert. An evasive maneuver is not necessary for a traffic advisory of this sort unless a potential hazard between two aircraft is visually determined, so our pilot begins to scan the skies for this potential intruder into our airspace.

The pilot, having neither seen the intruding aircraft nor received a follow-up Resolution Advisory (RA), concludes that this TCAS event must have resolved itself. Had this not been the case, the pilot would have maneuvered in response to the RA's instructions (e.g., "climb, climb") and communicated with the controller as soon as possible.

TCAS makes use of the radar beacon transponders, routinely carried by aircraft for ATC purposes of ID and altitude information, to provide vertical collision avoidance advisories. It functions, however, independently of the ground-based ATC system, which also alerts pilots to other traffic.

As TGA987 reaches the outer limits of the TRACON's control, TGA987 is vectored through a series of turns to position it to cross certain fixes in order to set up proper spacing of inbound traffic.

The aircraft is cleared for final approach, and communications and control are transferred from the TRACON to the tower. The fog has not lifted, and the low ceiling drastically reduces the pilots' visibility.

Fortunately, runway 28R at KSFO is equipped with a Category (CAT) III ILS, enabling the 747-400, with its advanced flight controls and avionics, systems to land even under these extreme weather conditions.

Runway configuration at KSFO does not permit the installation of a Precision Runway Monitor (PRM) system, which could have increased the airport's capacity by as much as 40 percent under these inclement conditions. This the U.S. fleet being FMS-equipped. This number will grow to about 50 percent by 1995.

The pilot notifies the tower of the plane's position. The local controller verifies via D-Brite, providing necessary advisories about weather and runway conditions, before clearing the plane to land.

Surface Movement (Arrival Phase)

Once on the ground, the pilot is instructed where to turn off the active runway. The pilot cannot see how to get to the gate because of fog, so a ground controller sequences the movement of TGA987 with other aircraft heading toward a gate or parking area.

A new Airport Surface Detection Equipment (ASDE-3) radar assists the controller in guiding our flight to its gate. With ASDE-3, controllers can monitor the airport surface during periods of poor visibility, preventing incursions of aircraft, and ground support vehicles, while expediting traffic flow. ASDE-3 will soon be installed at 29 airports. Procurement for additional systems is scheduled to begin in 1994.

By mid 1995, aural and visual alerts, provided by a new automatic monitoring system known as Airport Movement Area Safety System (AMASS), will warn controllers of possible runway incursions. KSFO is the first site slated for AMASS installation.

By 1996, a prototype Airport Surface Traffic Automation (ASTA) system, will combine ASDE/AMASS and transponder-based technologies to automate the activity of airport surface lighting systems that direct the movement of aircraft. ASTA will allow for safer movement of larger volumes of traffic between runways and gates in all-weather conditions.

TGA987: The Second Leg of the Journey

The preflight routine for the oceanic leg of the journey begins at the TGA dispatch office in KSFO. Twice a day, Oakland Center publishes optimum oceanic flight tracks for system users, based on the Dynamic Oceanic Tracking System's (DOTS) projections of jet stream winds and weather patterns.

After coordination with Oakland Traffic management, one of these "flex" tracks (so-called because they flex according to jet stream position) are chosen by the dispatcher for TGA987's flight route. Flying this track will minimize the effects of heavy head winds predicted for today over the extreme northern Pacific region.

A flight plan is filed, and it's "wheels up." ATC responsibility for TGA987 passes from the KSFO tower to the TRACON, then on to Oakland Center.

DOTS also has a track advisory function--a kind of airspace reservation service--that enables controllers to plan airspace usage more efficiently. DOTS "books" the specific time and altitude at which each transpacific flight is expected to cross a designated oceanic gateway. According to its flight plan, TGA987 has a negotiated, 10-minute window to cross the oceanic gateway fix "REDOO" and avail itself of the flex track DELTA. Later, it will in the Pacific in World War II. ARINC functions as an intermediary between the cockpit and ATC. The aircraft sends progress reports every 10 degrees (of approximately one hour) to ARINC.

Prior to ODAPS implementation, ARINC would have relayed these reports by teletype to the Oakland Center to inform ATC of a flight's position and altitude. Now, thanks to a one-way data link between the ARINC operator and ODAPS, these position reports are automatically translated into a representation of the plane's progress on the ODAPS Plan View Display (PVD) and controller's Cathode Ray Tube (CRT). By 1996 this data link will be two-way, but at present, the controller sends ATC instructions back to ARINC by phone, to be read to the cockpit over HF radio.

Because these transactions can take as long as 15 minutes to complete, very conservative aircraft separation standards are the rule in the oceanic environment--15 minutes in trail (one behind the other) or 100 miles laterally (side by side). Controllers are understandably limited in their flexibility to accommodate aircraft wishing to alter their flight paths or altitudes to maximize efficiency.

By 1996, an ADS enhancement will be added to the basic ODAPS architecture. This will be the earliest phase-in of ADS, which automatically transmits position reports, derived by onboard avionics, to Oakland Center via satellite data link. The capability to know an aircraft's position virtually real-time will revolutionize the oceanic ATC process and bring it closer to domestic radar environments.

Our TGA aircraft, one of the first 747-400s, was delivered to TGA without operational Satellite Communication (SATCOM) systems but will soon be retrofitted with this equipment.

TGA987's onboard flight management computers indicate that a climb from Flight Level (FL) 350 to FL 370 is necessary to minimize fuel burn and decrease head winds. But ATC denies the captain's request to climb, because an approaching aircraft is flying at the requested altitude.

That aircraft actually passes over our flight five minutes after the captain's request. Not until 15 minutes after the aircraft has passed, and a clearance to higher altitude can be issued, providing there is no other traffic. Had ADS been operational, the pilot would have been given instructions for a delayed climb to his preferred altitude, instead of being forced to operate at an inefficient altitude for an extended period.

A short while later, our pilot requests clearance to climb to FL 390, based on the flight's latest FMS profile. By now, the control of TGA987 has passed to Anchorage Center, a facility yet to be equipped with ODAPS. The pilot has a considerable wait while the controller verifies, by intensive manual calculation of flight trajectories, that this altitude change presents no potential conflict. By then, TGA987 is ready to pass into airspace controlled by Japanese ATC.

Anchorage Center also lacks an automated interface with the Tokyo Area Control Computer (ACC), necessitating a call from our controller to Tokyo on a voice circuit to request approval for the climb and to coordinate the exchange.

Soon controllers will have a new planning tool at their disposal, courtesy of ODAPS. Beginning in 1994, a conflict probe feature, now dormant in the ODAPS system, will be activated for controller use in determining if a request for altitude, speed or route change impacts other aircraft in the system. This will be strictly an advisory tool, not remarkable progress in the transition to space-based navigation and ATC management. Global navigation satellite services will be expected to provide a greater share of navigation for oceanic operations and domestic en route and terminal operations, including nonprecision approaches, as well as Category I precision approaches.

In the year 2000, communications have been transformed by aeronautical data link, which enables controllers and pilots to communicate routine messages over a digital channel. Computers select the optimum medium of transmission, choosing from VHF, Mode S data link or satellites.

While significantly decreasing controller workload, data link also increases the accuracy and reliability of communications. Frequencies are no longer tied up by transmissions requiring 15 to 45 seconds to complete (more if clearances need repeating), which is a lifetime to another aircraft with a problem. Data linked messages are also less prone to reception errors. Controllers need only type repetitive messages once into the ATC computer, which automatically sends them to multiple aircraft at appropriate times.

Data communications connectivity is provided by the ATN, which links aviation end-users around the world: ATC, onboard FMSs, ARINC, airline and airport operations. Real-time user data are transported from all sources, ground-based or airborne, and fed into a concentrator that packages it in high-speed, digitized data bursts. These are sent to an ATN router for forwarding to the computers of the appropriate end-user. Because complex information is now efficiently exchanged between ground and air, flight time reductions and fuel savings have resulted--enough to pay for the Mode S in a remarkably short period.

Increased automation and data link capabilities have changed the methodology of ATC, altering the role of both pilot and controller, who now share ground-based information, transmitted by fiber optic cables, and airborne information transmitted via satellite networks. Pilots have entered into a "limited partnership" with controllers--selecting traffic management options and, in certain instances, providing IFR separation between their aircraft and others. Controllers spend more time in strategic traffic flow management.

Consolidation has reduced the number of ATC facilities. Air route traffic control facilities continue to develop into Area Control Facilities (ACF's). Where operational and economically efficient arrival and departure facilities were merged to create large, regional terminal control facilities, known as Metroplex Control Facilities (MCF's). Local Control Facilities (LCF's) exist at numerous airports where consolidation into MCFs was not efficient. These LCFs are linked to the AAS via land-line connections.

Systems operations maintenance and infrastructure management are controlled real-time from operations control centers, which employ artificial intelligence, remote monitoring and diagnostics.
The AAS, implemented in stages over the last four years, is almost fully in place. An aggressive transition plan, forged in 1993, was instrumental in overcoming early difficulties in the ISSS program, resulting in on-time delivery of the promised computers and display consoles to controllers.

The Tower Control Computer Complex (TCCC)--brought full automation to towers, equipping controllers there with tools such as electronic flight data processing and voice recognition technology. Terminal operations were upgraded during the next stage of AAS development--the Terminal Advanced Automation System (TAAS)--as the collocation of some TRACONS was accomplished.

ground-based infrastructure.

As the NAS of tomorrow continues to evolve, new technology, impossible to foresee in 1993, will continue the trend of increased user flexibility with less need for control.

Preflight Activities

The generation of flight routes, departure instructions and clearances is now the job of FAA's TMP. Each scheduled flight is projected along a route direct to its destination and optimized for fuel efficiency, time en route, and separation requirements. Using data gleaned from ATC computers, new generation weather processors, airline schedules and flight plans, the TMP creates and maintains a dynamic, real-time model of the NAS. The TMP utilizes this model, which it updates every few minutes, to assign each aircraft its preferred route and projects time of arrival, with significant weather phenomena factored into the route.

The National Weather Service will provide high resolution guided aviation weather forecasts that will convert to specialized products for aviation users country of the new Aviation Weather Products Generator (AWPG).

The Departure Clearance Process

Clearances are still issued to all aircraft flying in the system, but most are now generated and delivered to the cockpit without controller intervention. ATC computers formulate preliminary clearances, placing them in a queue to be issued by data link either upon request or at predetermined times for scheduled aircraft, such as TGA987.

The majority of the information needed for our flight is pre-loaded and stored in FMS data bases, ready for activation at flight time. A taxi time is issued based on the allocation of airspace along the route of flight to the runway threshold of the destination airport.

Surface Movement (Departure Phase)

Automated tools and improved data sharing over the last few years have minimized the potential for runway incursions. A third-generation ASTA system now interfaces with the Terminal Air Traffic Control Automation (TATCA) system and TCCC to provide surface automation at KDFW. With the integration of these systems, surface traffic can now conform to traffic management initiatives.

A cockpit display of surface traffic data are available to pilots, who receive active taxi route guidance, including alerts for time-critical safety messages, via an aircraft/tower data link. Airport lighting is tied directly to the surveillance display and provides real-time status of movement on the runway. The net result is a well-choreographed airport surface environment, with no wait for runway access.

Airborne Phase

As the aircraft leaves the ground at the departure airport, it's placed under the direction of a radar controller. Data link is the principal means of communication between the pilot and controller. Voice communication is still

By 2000, terminal and en route operations have blended in what is best described as surveillance control--a combination of ADS and ground-based secondary surveillance. Aircraft routes are strategically managed from lift-off to touchdown, with a maximum six-second update from aircraft avionics to the controllers' display.

ATC facilities providing surveillance are, in most cases, remote from the airport. All phases of flight are controlled from these locations, with equal capabilities and service for all airspace under their control.

Now that aircraft fly user preferred optimum profiles, the concept of route structures has become an anachronism, except in close proximity to an airport. Sector and facility boundaries are dynamic, changing to accommodate demand and balance controller workload.

In the en route environment, our flight's conformance to the overall strategic traffic management plan is continually validated, based on a runway threshold crossing time at the destination airport (plus or minus 30 seconds). An early version of AERA software, now resident in ATC computers, checks for potential conflicts with other aircraft, severe weather phenomena and special-use airspace.

This tactical management tool projects a track of every aircraft 20 minutes ahead of its present position, based on flight plan data and aircraft performance characteristics. AERA calculates possible resolution scenarios to any potential conflict, prioritizes these solutions according to which have the least impact on the NAS and presents them to the controller for action.

Other automation enhancements in 2000 include TATCA, a set of software tools that manages arrival traffic streams using time-based separation. TATCA factors in maximum runway utilization rates, aircraft performance characteristics, and departure traffic schedules to produce a constant and orderly flow of traffic through the terminal area and down to the runway threshold. TATCA helps maintain the strategic ATC plan through five software aids: the descent advisor, the traffic management advisor, and a final-approach spacing tool, Expedite Departure Path (EDP), and Controller Automation Spacing Aid (CASA).

Descent advisories, provided as far out as 200 miles from KSFO, automate the function of guiding TGA987 into its approach profile. TATCA provides fuel-efficient descents from cruise altitudes using aircraft type-dependent fuel utilization models--in this case a model for a 747-400.

The traffic management advisory tool designs a steady flow of traffic to meet available capacity by displaying aircraft arrival times and landing sequence to the en route and terminal controller teams. Arrival plans are updated automatically based on surveillance-derived changes in aircraft locations and speeds, demand information, flight plans, and manually input data (e.g., runway configuration, visibility, and weather).

The expedite departure path tool provides controllers with optional advisories to integrate peripheral airport traffic wit the main airport traffic flow. CASA will use the converging runway display aid as the basis for developing "ghosting" applications. CASA will use the "ghosting" technique to merge traffic streams at a fix. The "ghosting" technique enhances a controller's ability to precisely space merging aircraft and thereby improve airspace utilization.

Once our aircraft is placed on final approach to its designated runway, the responsibility for ensuring separation and in-trail spacing is shared between the pilot and the controller. In-trail spacing is maintained with the aid of a TCAS-like system, using ground-based data uplinked to the aircraft. Both separation and delivery of aircraft to arrival runways are based on time and distance.

The approach navigational aid and precision landing system in most locations is a satellite-based Global Positioning System (GPS) with airport ground augmentation known as differential GPS to provide the necessary integrity, accuracy, and availability. Ground-based precision landing systems (ILS and Microwave Landing System (MLS)) are still available and will be relied upon until GPS augmented for Required Navigation Performance (RNP) is approved.

By the year 2000, national traffic management initiatives, such as those ATC restrictions imposed in our earlier scenario on arrivals at KSFO, are no longer employed. The TMP now manages all-weather traffic changes through AERA. Today, early warnings regarding low ceilings and rain at KSFO were coordinated through the TMP, which routed traffic accordingly through AERA. Furthermore, FMS-based landing procedures have been instituted, permitting the use of lower approach minima for those aircraft, like TGA987, with flight management computers.

OCEANIC PORTION OF THE FLIGHT

By 2000, oceanic flights are no longer tracked by means of hourly position reports filed by pilots via HF radio. Separation of aircraft is now achieved with almost the same degree of position accuracy as in the domestic system, using ADS.

Aircraft-derived position reports are transmitted air to ground at prescribed intervals by satellite data link without direct involvement of either the pilot or controller. FAA certification of SATCOM-equipped aircraft was partly responsible for early implementation of this capability.

Airlines have realized yearly savings on fuel costs of as much as $100,000 per aircraft from ADS procedures. In fact, the ability to transition promptly to more fuel-efficient altitudes has resulted in enough fuel savings in just two years time to reimburse TGA for the cost of SATCOMs equipment on their 747-400.

Participating nations are linked via SATCOMs systems, data links and international computer networks, so that information is shared by all principal international ATC providers. Aircraft fly minimum time track routes, just as they do domestically, to optimize fuel and time and maximize the use of both airports and airspace.

ACS	-	Assistant Administrator for Civil Aviation Security
ADS	-	Automatic Dependent Surveillance
AERA	-	Automated En Route Air Traffic Control
AF	-	Airway Facilities
AHR	-	Assistant Administrator for Human Resource Management
AIP	-	Airport Improvement Program
AIT	-	Assistant Administrator for Information Technology
AMASS	-	Airport Movement Area Safety System
AND	-	Associate Administrator for NAS Development
API	-	Assistant Administrator for Policy, Planning, and International Aviation
ARAC	-	Aviation Rulemaking Advisory Committee
ARINC	-	Aeronautical Radio Incorporated
ARP	-	Assistant Administrator for Airports
ARTS	-	Automated Radar Terminal System
ASC	-	Office of System Capacity and Requirements
ASD	-	Associate Administrator for System Engineering and Development
ASDE-3	-	Airport Surface Detection Equipment
ASR	-	Airport Surveillance Radar
ASTA	-	Airport Surface Traffic Automation
ATC	-	Air Traffic Control
ATCSCC	-	Air Traffic Control System Command Center
ATM	-	Air Traffic Management
ATN	-	Aeronautical Telecommunications
AVR	-	Associate Administrator for Regulation and Certification
AVS	-	Associate Administrator for Aviation Standards
AWPG	-	Aviation Weather Products Generator
AXD-4	-	Chief Scientific and Technical Advisor for Human Factors
AXO	-	Executive Director for System Operations
AXQ	-	Executive Director for Acquisition and Safety Oversight
CAT	-	Category
CDT	-	Controlled Departure Time
CDTI	-	Cockpit Display of Traffic Information
CIP	-	Capital Investment Program
CNS	-	Communication, Navigation, and Surveillance
COTS	-	Commercial-off-the-shelf
CTAS	-	Center TRACON Automation System
D-BRITE	-	Digital-Brite
DF	-	Direction Finding
DME	-	Distance Measuring Equipment
DOD	-	Department of Defense
DOS	-	Department of State
DOTS	-	Dynamic Oceanic Tracking System
EDS	-	Explosive Detection System
EI	-	Employee Involvement

GNSS	-	Global Navigation Satellite System
GPS	-	Global Positioning System
HF	-	High Frequency
ICAO	-	International Civil Aviation Organization
ID	-	Identification
IFR	-	Instrument Flight Rules
ILS	-	Instrument Landing System
IMC	-	Instrument Meteorological Conditions
ISSS	-	Initial Sector Suite System
IWG	-	Issue Working Group
KDFW	-	Dallas/Fort Worth International Airport
KSFO	-	San Francisco International Airport
LCF	-	Local Control Facility
LDA	-	Localizer Directional Aid
MCC	-	Maintenance Control Center
MCF	-	Metroplex Control Facility
MLS	-	Microwave Landing System
Mode S	-	Mode Select
NAS	-	National Airspace System
NASA	-	National Aeronautics and Space Administration
NAVAIDs	-	Navigation Aides
NDB	-	Non-directional Beacon
NEXRAD	-	Next Generation Radar
NSDD	-	National Security Decision Directive
ODAPS	-	Oceanic Display and Planning System
OPR	-	Office of Primary Responsibility
OPMT	-	Operational Planning Management Team
OST	-	Office of the Secretary of Transportation
P.L.	-	Public Law
PDC	-	Predeparture Clearance
PFC	-	Passenger Facility Charge
PRM	-	Precision Runway Monitor
QTP	-	Quality Through Partnership
R&D	-	Research and Development
RA	-	Resolution Advisory
SAFI	-	Semi Automatic Flight Inspection
SATCOM	-	Satellite Communications
SDF	-	Simplified Direction Finding
SPEARS	-	Screener Performance Evaluation and Reporting System
TAAS	-	Terminal Advance Automation System
TATCA	-	Terminal Air Traffic Control Automation
TCAS	-	Traffic Alert and Collision Avoidance System
TCCC	-	Tower Control Computer Complex
TDWR	-	Terminal Doppler Weather Radar
TGA	-	TransGlobal Airlines

development and for subsequent investment decisions.

Because of the capital improvements and research and development efforts underway in the United States and abroad, as well as the work of the Future Air Navigation System (FANS) Committee of the International Civil Aviation Organization (ICAO), the outline of the future system leading into the early 21st century is becoming quite clear. Its benefits may come sooner than many anticipate.

The scope of the National Airspace System (NAS) and the FAA's Research and Development Program comprises technical disciplines and issues beyond air traffic management including aviation security, airworthiness and certification of new aeronautical technologies, airport technology and standards, aviation medicine, and aircraft emissions and noise. This chapter focuses on air traffic management.

In accordance with practices that have evolved in a number of forums dealing with the future of traffic flow management and control, we must distinguish among three processes. The term "air traffic control" refers to the tactical safety separation service that prevents collisions between aircraft and between aircraft and obstructions. The term "traffic flow management" refers to the process that allocates traffic flows to scarce capacity resources. "Air traffic management" is the composite process ensuring the safe, efficient, and expeditious movement of aircraft. Air traffic control and traffic flow management are components of the air traffic management process.

Fundamental Requirements

International Scope

The air traffic management system of the 21st century, like aviation itself, must and will be international in scope. The fundamental technologies, procedures, and systems must be compatible worldwide. Satellite technology will become increasingly attractive and will provide broad regional, even worldwide, services.

The evolutionary future system design must meet the test of international acceptance and interoperability. It must allow for implementation at various levels of sophistication to provide various levels of service tailored to specific applications.

**Adapted from "Concepts and Description of the Future Air Traffic Management System," Federal Aviation Administration, April 1991.*

service systems because the two operate simultaneously, side-by-side, during the transition period. For new systems where no current in-service equivalent exists, the transition burden is less.

While change in the system will be evolutionary, the design for the future must provide a well-understood, manageable, cost-effective sequence of improvements that keeps pace with user needs and culminates in a system meeting the safety, capacity, efficiency, and environmental demands of the early portion of the 21st century.

Service to a Broad User Spectrum

The system must accommodate a broad spectrum of users and various levels of avionics equipment. User categories include single-engine general aviation aircraft, sophisticated business aircraft, helicopters, the whole range of commercial aircraft operating in a variety of environments, and military aircraft of all types. In the future, advanced subsonic transports, second generation supersonic transports, and hypersonic aircraft will be added to the environment.

In a typical year, 46 million hours are flown in the NAS of which 13 million (28 percent) are flown by scheduled operators. The remaining 72 percent of the airspace use is by nonscheduled operators (57 percent general aviation and 15 percent military). Clearly, the system of the future must do more than accommodate the nonscheduled operator; it must be user friendly and promote its use by the entire community.

Outline of the Future System -- Is It Clear or Cloudy?

The outline of the future system leading into the early 21st century is fairly clear. It will evolve from the system modernization effort currently underway in the Capital Investment Plan; its design will be based on user needs and the technology opportunities for meeting those needs. While new technology breakthroughs are always welcome and all must be continually alert to such developments, one simply cannot plan on what is not known. Thus, the current thinking for the future system is based on the technology opportunities that are apparent now.

A major design challenge in the development of air traffic management procedures and techniques using new technologies to realize system improvements centers on the roles of the human operators. Information provided to these individuals and the tasks assigned must be consistent with their management and control responsibilities, as well as the innate characteristics and capabilities of human beings. As basic understanding of human factors improves and facilities for testing the human factors aspects of system designs become available, the design process will become easier.

- Increase system capacity and fully utilize capacity resources as required to meet traffic demands in all visibility conditions;

- Better accommodate user-preferred flight trajectories (e.g., cruise-climb vertical profiles following direct routes);

- Better accommodate the full range of aircraft types and avionics capabilities;

- Improve aviation information for users, including weather observations and forecasts, traffic congestion and delays, status of NAS facilities and airports, and in-flight situational awareness based on cockpit display of traffic information;

- Improve navigation and landing capabilities, including curved approach, missed-approach, and departure guidance and eventually a satellite-based capability approaching Category I. Category II precision operations should be supported at all airports serviced by air carriers with Category III provided at the pacing airports;

- Increase user involvement in decisionmaking, including computer-based, air-ground negotiation of flight trajectories.

System Design Considerations

A number of system design considerations deserve discussion, in particular:

- The environment in which the aircraft operate and the best ways to improve the quality and timeliness of the information on the environment that both aircraft and the air traffic management system must use;

- Information on traffic flows en route, in transition, approaching the airport, and on the airport surface, as well as dynamic information on current and projected capacity resources and ways to improve the quality and currency of this data;

- Information on the positions and maneuver intentions of aircraft and the ways this information can be used best within the air traffic management system;

- The procedures and separation standards which affect airspace capacity and ways to improve them;

- The use of automation tools to help sort, process, and manage the mass of information required to best utilize available airspace and airport resources.

and the existence, strength, and transport of wake vortices.

The future terminal area/airport air traffic management system can be no better than the information available to it. The task is to develop and implement better sensors and the information transfer (communications) that enables the information to be used more efficiently by people and computers.

A part of the development of improvements is the selection of the best sources of information. An increasing percentage of the commercial aircraft fleet is equipped with both inertial reference navigation systems and data link communications. These aircraft can automatically communicate instantaneous wind information and other data about the environment in which they fly and the environmental impacts they bring (wakes, achievable stopping distance on reduced friction runways, etc.). The future system will selectively utilize this aircraft data to augment the ground-derived arsenal of environmental information.

Traffic Flow Management Information

If the system is to operate efficiently, there is great benefit to a traffic flow management process that smoothes the flow of aircraft to avoid unacceptable levels of traffic congestion.

Several ingredients are important. The traffic flow management system is heavily dependent on the environmental information described above and can be no better than the data available to it.

Because long-term forecasts are not perfect and will not become perfect, it will remain important to arrange aircraft flows to take advantage of the adaptability of the terminal area/airport system. While terminal area holding and delay-absorbing terminal maneuvers are not desirable, some may be necessary to make best use of terminal area/airport capacity.

As an aid to traffic flow management in the future system, real-time automation tools are required to assimilate the mass of information and to offer flow strategies which take full advantage of changing terminal area and airport conditions. Because aircraft themselves have sophisticated flight management systems which can adapt to changing situations and will be in automatic communication with the ground, they will be valuable partners in the traffic flow management decisionmaking process.

The traffic flow management process, whether central or local, depends heavily on current actual and short-term predicted airport capacities. These capacities in turn depend on environmental factors as well as on the airport circumstances--runways and facilities available or out, runway configuration strategy, special noise considerations, the wake separation requirements of the aircraft currently in the system, taxiway/holding area availability, and other factors. The future system will have available to it the best possible data on actual and short-term-projected airport permits planning in the aircraft and in the air traffic management system. It should be an airspace structure which can dynamically adapt to changing circumstances, which accommodates the capabilities and desires of the aircraft users, and which utilizes data available in the aircraft.

As before, the quality of the process begins with the quality of position information available to the system and the flight crews.

In the future system, the basic source of accurate aircraft position data will be the altitude-reporting secondary surveillance radar (SSR) transponder. Other sources of position data, such as relay of aircraft-derived navigation position (using GNSS, the Global Navigation Satellite System), may come into use and should be acceptable if their accuracy, availability, and integrity are proven adequate, but SSR Mode S surveillance will be the standard for high traffic terminal area operations.

Accurate surveillance information will increasingly be required on the airport surface as well to support automation of the on-airport air traffic management process at the busiest airports. The sources of choice for this service will be airport surface detection radar augmented by: a) positive identification using the Mode S system in a multilateration mode (requiring no change to the SSR transponder; or b) transmissions from aircraft of GNSS position data.

Procedures and Separation Standards

The air traffic management system is fundamentally a system of rules and procedures scrupulously applied to achieve a safe system in which all participants understand their responsibilities.

The new technologies and aircraft capabilities will require changes to the rules and the approach to them, because the new capabilities permit far more cooperative arrangements than before. The introduction of cockpit traffic displays will involve the aircraft crew in the air traffic management process in new ways.

Because separation standards have an important influence over the capacity and functioning of the future system, it will be necessary to develop comprehensive, reliable models for determining separation standards applicable to new technologies and procedures.
An important additional initiative will be to improve this process of procedure development so that users contemplating investment in new technology can have reliable guidance on the credit they will receive for a new capability before they make the investment.

The future traffic flow management process will be based on comprehensive data bases describing current and projected levels of demand and capacity resources. Sophisticated models that accurately predict congestion and delay will be used to formulate effective real-time strategies for coping with excess demand. Users will interface with the traffic flow management process in flight planning to negotiate trajectories that best satisfy their needs while meeting capacity constraints.

The air traffic control process, which monitors the progress of individual aircraft and intervenes in their flight paths when required, also will make extensive use of automation. When a user determines that a flight-plan amendment is required, a communication process will be established between the aircraft's flight management computer system and the ground-based automation to recommend a new trajectory that best meets the user's objective and satisfies air traffic management constraints (e.g., special use airspace restrictions). Similarly, when the ground-based air traffic control process recognizes a need to intervene in the cleared flight path of an aircraft, the automation computer will communicate with the flight management computer to recommend a modification meeting the constraints with the least disruption to the user's preferred trajectory. Human operators will exercise management and control authority over these communication processes.

Aircraft not equipped with flight management computers capable of communicating with air traffic management automation will communicate with the ground-based system via data link and voice channels. Ground-based automation aids will be available for use in developing flight-plan amendments and control instructions with these operators.

Where effective, four-dimensional clearances will be used to accurately position aircraft in time to resolve conflicts and to schedule use of scarce capacity resources such as runways.

System Operations

Navigation and Landing

The GNSS will be the principal radionavigation aid used by aircraft in oceanic, en route, and terminal airspace, including departure operations. Approach and landing capability equivalent to Category I will be provided by the GNSS in combination with ground-based equipment providing differential corrections to the ranging signals available from the satellites. Category II and III equivalent approach and landing capabilities may also be provided by GNSS augmented by ground equipment or, alternatively,
by the Microwave Landing System.

High frequency communications in polar regions will remain part of the system for the foreseeable future. Very high frequency (VHF) voice and data communications will continue to be used as well. In the future, satellite communications will be used extensively for both air traffic management and commercial (i.e., user operational) purposes.

Data link will be commonplace for air traffic management operations, utilizing Mode S and other high-integrity media for data transfer between the ground and the flight deck. Open System Interconnection techniques, conforming to internationally accepted technical standards, will be fully developed and incorporated into the aviation data link design to assure interoperability of satellite, Mode S, VHF, and terrestrial data transmission systems.

Data link applications will include weather and Notice to Airmen information, clearances, flight plan data, information for flight management computers and inertial reference systems, weight and balance data, engine performance monitoring, and technical assistance.

Surveillance

The ground-based surveillance system will evolve to rely more on SSR and less on primary radar. For the immediate Future, primary radar will continue to be used in terminal areas to detect aircraft mistakenly entering terminal control areas and as a back-up in the event of transponder failures.

High data rate SSRs will be used for monitoring aircraft approaching closely spaced parallel runways. Mode S transmission of GNSS-derived position may eventually replace these radars. Surveillance over the ocean and in low density en route airspace will be provided by satellite-based Automatic Dependent Surveillance (ADS). This involves reporting to the ground, via data link, the aircraft position as determined by the onboard navigation system. ADS will provide real-time surveillance information in airspace where this information would not be available otherwise.

The need for airport surface surveillance will increase as airports grow in size and operational complexity and the requirement for all-weather operations grows. Primary radars and secondary surveillance techniques using Mode S technology will be employed. Mode S techniques will provide aircraft position information and flight identification (e.g., "UAL 52") which are essential for automating surface traffic operations.

Weather

Improved weather sensors and the integration of weather sensor data to provide comprehensive, timely, and reliable predictions of weather phenomena will be a major new feature of the future system. New Doppler radar systems optimized for weather detection using both rotating operators, flight planning services, and air traffic management facilities.

Collision Avoidance and TCAS

The Traffic Alert and Collision Avoidance System (TCAS) will continue to provide an airborne collision avoidance capability. It is envisioned that TCAS, in combination with ADS and improved navigation from the GNSS, will enable reduction of lateral and longitudinal separation standards, especially in oceanic areas.

In addition, TCAS technology will support a display of traffic information to improve situational awareness in the cockpit. Cockpit traffic displays are likely to be used in various operational scenarios. In terminal airspace, flight crews may use the traffic display for in-trail stationkeeping on arrival and for separation monitoring on departure to manage interaircraft spacings. In addition, the display may be used for monitoring the positions of proximate aircraft on approaches to closely spaced parallel and converging runways to facilitate these operations at lower weather minima than would be possible otherwise.

Flight Planning

IFR operations in the future system will continue to be based on filed flight plans. These flight plans will result from negotiations between the user and the air traffic management system wherein the user has been provided comprehensive, reliable information on weather, system congestion and delays, and the status of pertinent airports and facilities. The flight plan will represent the best accommodation of the user's preferred trajectory given the air traffic management constraints that apply.

Users will interact with FAA flight planning services either directly via computer terminals or person-to-person through flight service specialists.

Oceanic Operations

International Air traffic is growing at a rate far exceeding the growth in domestic activity. This area provides a full breadth of opportunity to benefit from new technologies and will experience significant improvements through the next decade. The overall goal will be to make oceanic operations as flexible as reasonably possible in accommodating users' preferred trajectories.

Future oceanic operations will make extensive use of ADS, satellite-based voice and data link communications, the GNSS, cockpit traffic display, aviation weather system improvements, and automation, including the integration of air traffic management automation and flight management computer operations via data link. These new capabilities will permit flexible routing and dynamic modifications to aircraft routes in response to changes in weather and traffic conditions.

management computers will be principal tools in assuring that all traffic management constraints are met with the least disruption of user-preferred trajectories.

Terminal and en route automation functions will be integrated to provide a system in which traffic flows smoothly into and out of terminal areas. Military airspace requirements and utilization will be fully coordinated with the civil system to assure that airspace not in use by DOD is available to accommodate civil traffic demand.

Terminal arrival sequencing is accomplished using ground automation, taking individual aircraft performance into account. The sequence will be determined which minimizes total delays for all arriving aircraft. User preferred trajectories and tactical separation will be accommodated until arrival at a metering fix on the final approach at assigned final approach time, which optimizes runway throughput.

Data link will be used to transmit weather observations from appropriately equipped aircraft and to provide a variety of aviation information to the cockpit including weather products and the status of facilities and airports.

En route airspace capacity will be substantially improved by reducing the vertical separation standard above 29,000 ft. to 1000 ft.

Airport Operations

Increased airport capacity and improved safety will be major objectives of the future system. The design of the future system will contribute to this goal by utilizing techniques, procedures, and technologies that allow a higher throughput of traffic, that fully utilize scarce capacity resources, and that structure traffic flows to maximize both approach and departure operating efficiencies.

The use of curved approaches will eliminate some of the constraints imposed by centerline approach procedures dictated by the limitations of contemporary landing systems. In certain situations this will be essential to eliminate conflicts among approach operations involving different airports and will allow each airport to run independently. These techniques also will allow added flexibility in reducing the noise footprint of airport traffic operations.

Independent IFR approaches to parallel runways spaced as closely as 2500 ft. will be routine based on high data rate SSRs or through GNSS position data transmission. This will provide capacity increases of 30 percent in instrument meteorological conditions (IMC) at locations with such runway configurations. In addition, many communities will take advantage of this new capability by constructing new closely spaced parallel runways that conserve airport real estate. Automation tools will assist in establishing efficient approach streams for parallel and converging runway configurations.

to their assigned routes, and alerting air traffic managers when aircraft are out of conformance. Assigned taxi routes will fully utilize the capacity of the airport surface to accommodate demand and will assure that departure sequences effectively utilize downstream terminal and en route airspace capacities in accordance with traffic flow management strategies.
On the airport surface, suitable-equipped aircraft will use cockpit displays showing a map of the airport surface with the assigned taxi route superimposed, including intermediate clearance limits such as hold short points. The display will also show the positions of proximate aircraft. The airport map data may be stored in the flight management computer. The aircraft position on the map might be determined using the GNSS with the positions of proximate aircraft determined using TCAS technology. The purpose of the display would be to aid navigation, improve situational awareness, and aid the flight crew in maintaining separation from other aircraft in all weather conditions.

Data link will be utilized extensively on the airport surface for delivering predeparture and taxi clearances and for guiding aircraft along their assigned taxi routes, including flight crew alerts when aircraft are out of conformance. Signs and signal lights, including sequenced taxiway centerline lights and stop bars, also will be used extensively on the airport surface for taxi guidance and to indicate the status of runways and taxiways. Data link will provide flight crews with hard copies of terminal information on arrival as well as alerts of severe weather conditions such as windshear. Data link will dramatically reduce communications workload and the number of communications errors in comparison with today's voice environment.

Improved metering, sequencing, and spacing of arrival traffic will increase single-runway capacities in IMC to a level approaching single-runway capacities in visual meteorological conditions today. Independent IFR operations on triple and quadruple parallel runways will be routine.

Reaching Community Consensus on Development Directions

The development of the future system design is an aviation community undertaking. It is envisioned that aviation community representatives will participate in FAA future system definition activities, in particular, in the activities of the National Simulation Lab.

Legitimate community interests include the identification of system design alternatives; evaluation of the alternatives; selection of promising designs for further development; and establishment of system enhancement goals, including the associated schedules. System design features that offer operational advantages for one user group may appear to penalize the operations of another. The selection of a future design therefore should be a continuing community process based on the best possible understanding of the characteristics of the alternatives. All community members have a stake in the outcome.

A large number of technology opportunities present themselves for improving air traffic management services to better meet user requirements. The principal opportunities are satellite-based communications, navigation and surveillance services; automation, including the integration of air traffic management automation and flight management computer operations via data link; and new capabilities for sensing and forecasting weather.

The emerging technologies will support a variety of future system designs. The challenge before the U.S. and international aviation communities is to develop an adequate understanding of the costs, benefits, and operational suitability of these design alternatives and to orchestrate a coordinated program of improvements that takes into account user needs, the willingness of users to upgrade their capabilities to achieve operational benefits, and the capital investment resources of air traffic management service providers. The technologies are identified; the task is to manage their application to increase the safety and efficiency of flight operations.

The FAA, in collaboration with users, industry, academia, other government agencies, and the international aviation community, plans to provide leadership in formulating and evaluating future system designs based on user needs and evolving technology opportunities and in coordinating community efforts to realize the associated air traffic management capabilities and operational benefits.

satellite technology. The FAA has responded to this through initiation of a comprehensive satellite program involving government, industry and users to expedite research, development and field implementation of satellite-provided navigation services.

Several parallel activities have been initiated.

- The *FAA Satellite Navigation Program Plan, FY92-97* (February 1992) was prepared to present needs, scope, objectives, comprehensive schedules and other requisite planning information.

- The FAA established a Satellite Operational Implementation Team (SOIT) to facilitate the introduction of satellite navigation and communications into the National Airspace System. The team consists of FAA experts in avionics certification, operational approval, instrument flight procedures and other areas. The team has participated in the drafting of a Technical Standard Order (TSO) on the use of Global Positioning System (GPS) as a supplemental means of navigation, and it is evaluating a concept where GPS nonprecision approaches can be approved as overlays to present nonprecision approach procedures (except for Instrument Landing System (ILS) localizer- based approaches).

- An RTCA Task Force was established to develop the necessary system requirements to achieve various applications, such as navigation for all phases of flight, automatic dependent surveillance, runway surface position determination and surveillance, and search and rescue. Results of this activity will include projected operational benefits, a transition strategy for early implementation, phase out of unneeded air navigation aids and institutional arrangements.

- To assist the Task Force, a paper, *Achieving Early Use of GNSS: An FAA Perspective* (December 1991) was prepared to provide an FAA perspective for achieving use of GPS over the next ten years. That paper presented the FAA's view for resolving concerns about meeting National Airspace System (NAS) requirements for integrity, accuracy and availability, and transition from the current ground-based systems. It also describes user and FAA roles and responsibilities, and FAA Satellite Program Office support for achieving early implementation.

The following paper supplements the above discussed "Achieving Early Use" paper. Its intended audience is the civil air navigation users, manufacturers, and FAA operational and navigation performance (RNP) for all phases of flight. An RNP system is a navigation system that meets the accuracy, integrity and availability/continuity of service requirements without the support of any other navigation system. An RNP system may include one or more navigation sensors in its definition (e.g., GPS/inertial reference system). In contrast, a supplemental navigation system requires the presence of an RNP system as part of the on-board navigation system.

The paper is not speculative in that it does not discuss requirements for more stringent services beyond Category I precision approaches. As technology improves and more experience is gained in satellite navigation operations, applications to precision approaches beyond Category I are expected to evolve. The stated target dates for operational implementation are based on the aforementioned *FAA Satellite Navigation Plan, FY92-97*.

INTRODUCTION

Over the years, various ground-based radionavigation systems have been implemented to provide reasonably precise and reliable positioning information for navigation. Systems such as VOR/DME, Loran-C, Omega and ILS have provided navigation capabilities, but for some phases of flight all are limited in either coverage or accuracy, or both. Therefore users must carry several types of receivers to obtain navigation service for all phases of flight.

The future vision for navigation rests with the use of satellite technology to provide continuous, reliable, accurate positioning information for all phases of flight to users worldwide. The foundation for this vision is the GPS, a satellite-based radionavigation and time transfer system operated and controlled by the U.S. Department of Defense (DOD). Planned to be declared operational in 1993, GPS will consist of 21 satellites. Then an additional three active spares will be implemented to ensure the high availability of at least a 21-satellite constellation.

Because GPS satellite signals are propagated independent of the ground and employ a signal structure that permits accurate range and range-rate measurement to each satellite, signal propagation problems that affect the accuracy of the land-based systems can be minimized. GPS accuracy is affected by various factors, including satellite clock errors, satellite position errors, receiver errors, and tropospheric/ionospheric conditions. However, the most significant potential error source is selective availability, an intentional degradation of the GPS signals that DOD is using to prevent hostile forces from gaining the benefits of GPS positioning.

will normally be degraded by selective availability.

- The more accurate Precise Positioning Service (PPS) will be limited to military and authorized civil users only.

While GPS without any augmentations represents a significant improvement over existing methods of navigation, it has limitations for use in civil aviation. These include the following:

- Since the satellites rotate about the earth in inclined orbits, the availability of at least 4 satellites with sufficient geometry for position determination is a function of user location and time, as well as the satellites' reliabilities. A coverage outage due to failed satellites can encompass a very wide area for several minutes until a new satellite rises into view.

- Signal integrity is monitored on board the satellites and by the GPS operational control segment. The on-board monitoring can detect less than half the signal failure modes. Although the operational control segment can detect all failure modes, its response time in issuing warnings to users through the satellites is of the order of an hour, whereas civil aviation's requirement is of the order of seconds. Signal integrity can be determined within the user receiver by algorithmic techniques called receiver autonomous integrity monitoring (RAIM). However, RAIM without aiding from any other systems requires the reception of at least five satellites with good geometry to permit detection of a violation of GPS position error tolerance. At least six satellites are required for identification of a malfunctioning satellite. In RAIM use for nonprecision approach, at least five satellites are unavailable four percent of the time and at least six satellites with sufficient geometry are unavailable more than 50 percent of the time in the planned 21 plus 3 active spare constellation.

- GPS SPS provides highly accurate coverage for the oceanic en route, continental en route, terminal, and nonprecision approach phases of flight. However, its 95 percent vertical accuracy is not sufficient for precision approach and its availability is not sufficient for all weather landing operations.

For the above reasons, the FAA is evaluating a number of candidate configurations in which the GPS SPS is augmented by various systems. Moreover, the future vision for satellite

The GPS SPS even without augmentation, offers substantial benefits to civil aviation users. The system has the potential for use by almost anyone, since today's integrated circuit and microprocessor technology means that GPS receivers are small and low cost enough for widespread use.

The following candidate augmentations for GPS are designed to overcome the limitations summarized earlier.

GPS with Altimeter Input. FAA analysis indicates that GPS augmented with barometric altimeter will significantly increase the availability of RAIM during those periods when the satellite geometry is not sufficient.

GPS Integrity Channel (GIC). To further increase the availability of GPS integrity, the FAA is investigating the implementation of a network of 6-10 ground monitors covering the conterminous United States (CONUS), see figure 1. These monitors would disseminate integrity information on each GPS satellite via geostationary satellite relays. It is expected that eventually, there would be a worldwide network of GIC monitors. In the presence of selective availability with GIC and at least 4 satellites in view with good geometry, GPS would be usable for all phases of flight, except precision approach.

GPS and Inertial Reference System. Many air carriers and business aircraft are fitted with inertial systems. It has long been recognized that a combination of GPS and an inertial reference system is more accurate than inertial navigation alone and provides notably better availability than GPS alone. However, in the presence of selective availability this hybrid configuration will not meet precision approach accuracy and integrity requirements without differential GPS augmentation (see below discussion of differential GPS).

GPS and Loran-C. Loran-C is a supplemental radionavigation system requiring signals from at least three ground transmitters for position determination. Integrity monitoring for the radiated signals is provided by the U.S. Coast Guard and the FAA. Loran-C is not as accurate as GPS. It also does not enjoy the worldwide coverage of a satellite navigation system, and in many areas there is a lack of redundant signal coverage. While forfeiting some of GPS's accuracy, an integrated GPS/Loran-C will have an availability significantly greater than that of either system alone and can be used for all CONUS navigation service except precision approaches.

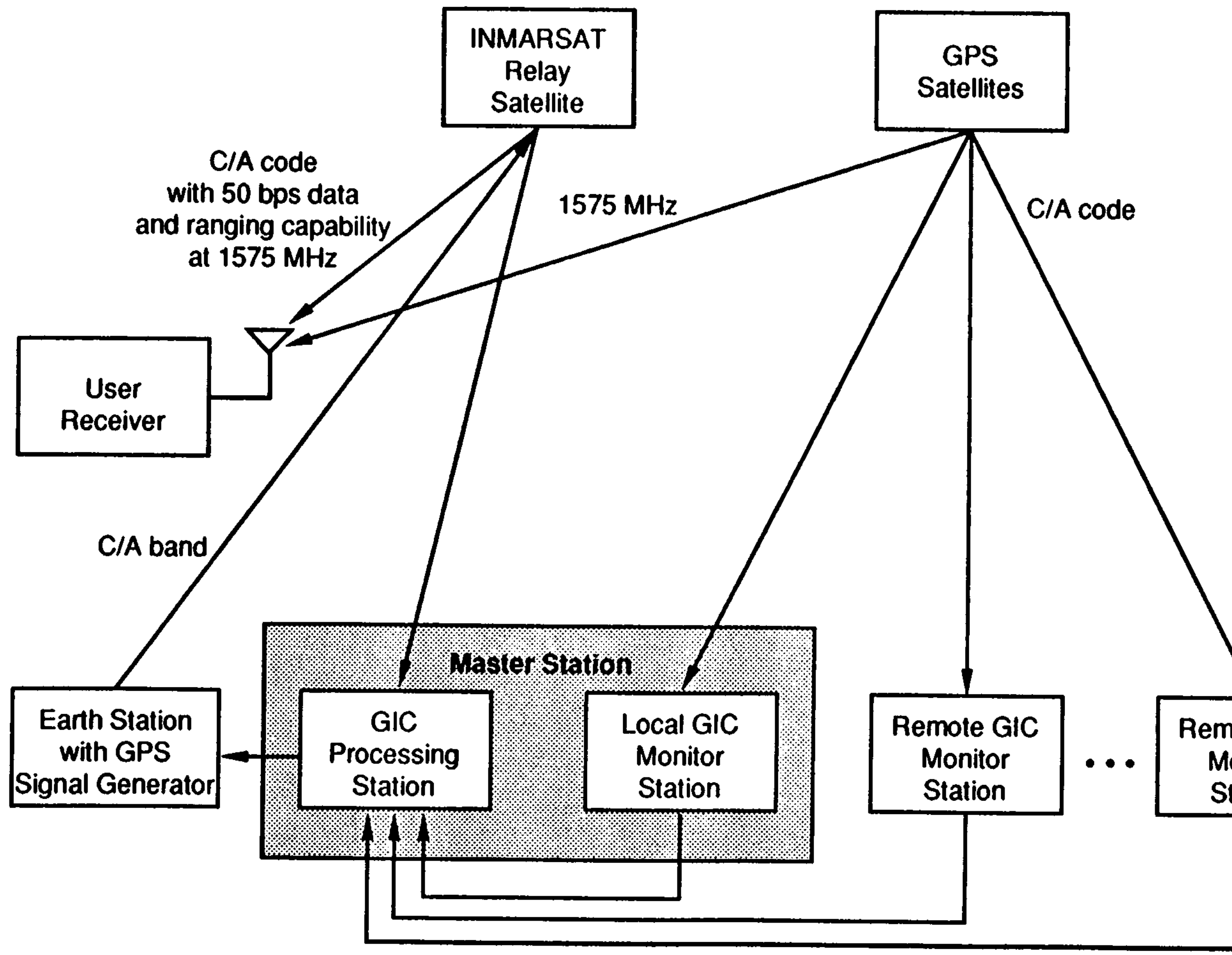

Figure 1. Preferred GIC System Configuration

GPS/GLONASS capability, users will have a significantly greater number of satellites in view continuously. This will provide sufficient RAIM availability for all phases of flight up to nonprecision approach. Thus, this double-satellite combination could eventually evolve into the envisioned GNSS for all phases of flight with the possible exception of precision approaches.

Differential GPS for Precision Approach. Differential GPS involves the use of GPS ground monitors at known locations to determine the errors in the satellite signals and to transmit error correction messages. Differential GPS will make it possible to conduct precision approaches at any runway within the coverage area. Important safety benefits will result because both horizontal and vertical center line guidance will be provided throughout the approach, no alignment or transition is required. Moreover, if aircraft can be directed to all available runways during instrument meteorological conditions, significant improvements in capacity and terminal airspace utilization will be possible. Differential GPS may also be used for airport surface position determination and situational awareness, and as a sensor for automatic position reporting for airport surface surveillance. In combination with differential GLONASS this configuration may provide sufficient availability for RNP precision approaches.

REALIZATION OF THE VISION

This section details the role for GPS and the various augmentations discussed above in the NAS as envisioned by the FAA. This section is written from a user perspective to clarify the type of service available from a particular GPS configuration.

GPS With Altimeter Input

GPS has already been approved as one of the multisensor inputs to a flight management computer. This use of GPS will enhance the worldwide navigation accuracy of those users equipped to process multisensor inputs. However, as noted earlier, the low availability of a sufficient number of extra satellites for RAIM means that GPS without any augmentations will have limited availability. The FAA draft TSO for supplemental navigation requires approved GPS receivers to accept barometric altimeter inputs to its RAIM algorithm. The purpose of this recommendation is to increase system availability by providing RAIM "coasting" capability if there is satellite geometry deterioration due to a satellite failure. As a supplemental system, GPS with altimeter input will use RAIM for the detection of the violation of position error tolerance. By the end of 1993, implementation will be started for GPS use as a supplemental navigation system for the oceanic en route, domestic en route, terminal and nonprecision approach phases of flight .

geostationary satellite position, the GIC broadcasts would also provide additional GPS ranging signals for increased availability. Starting in the mid-1990s, Inmarsat will be implementing GIC payloads on their next-generation satellites. Figure 2 shows a coverage diagram of the Inmarsat GIC broadcast. Note that the middle part of the U.S. is covered by only one satellite; therefore, this configuration has a single point of failure and would not provide sufficient availability of the GIC function.

Also, the wide-earth coverage of the satellites would require that the GIC implementation be an international effort, especially since there are no other such planned satellite implementations at this time. The FAA has an experimental program underway to investigate the feasibility of GIC. If feasible, the FAA also plans to encourage other satellite communications service providers to carry GIC payloads to increase the redundancy of the system.

Even with GIC augmentation, however, the percent unavailability of position determination accuracy as a function of phase-of-flight requirements may not permit GPS to be certified as an RNP system without other augmentations. An operating GIC would facilitate the necessary other augmentations, such as GPS/IRS, to provide RNP capabilities for all phases of flight with the possible exception of precision approach. If GIC is adapted its target year for operation is 1998.

GPS and Inertial Reference System (IRS)

As discussed earlier, a combination of GPS and an inertial reference system provides greater accuracy than inertial navigation alone and greater availability than GPS alone. This is due to the complementary low-error, short-term characteristic of the inertial system and the low-error, long-term characteristic of GPS. For example, GPS can be used to update the inertial system with GPS accuracy prior to a short-term unavailability of a sufficient number of GPS satellites. Furthermore, for approach, the inertial system provides a means for smoothing higher-frequency GPS errors that need to be minimized, and provides continuity-of-service improvement, especially for any momentary loss of satellite signals. Industry has produced integrated GPS/inertial systems that are currently under operational test and evaluation for all phases of flight. Triple-inertial systems are certified for the oceanic phase of flight and when integrated with ILS for autoland; other than for flight control system applications, they have not been generally certified for other phases of flight.

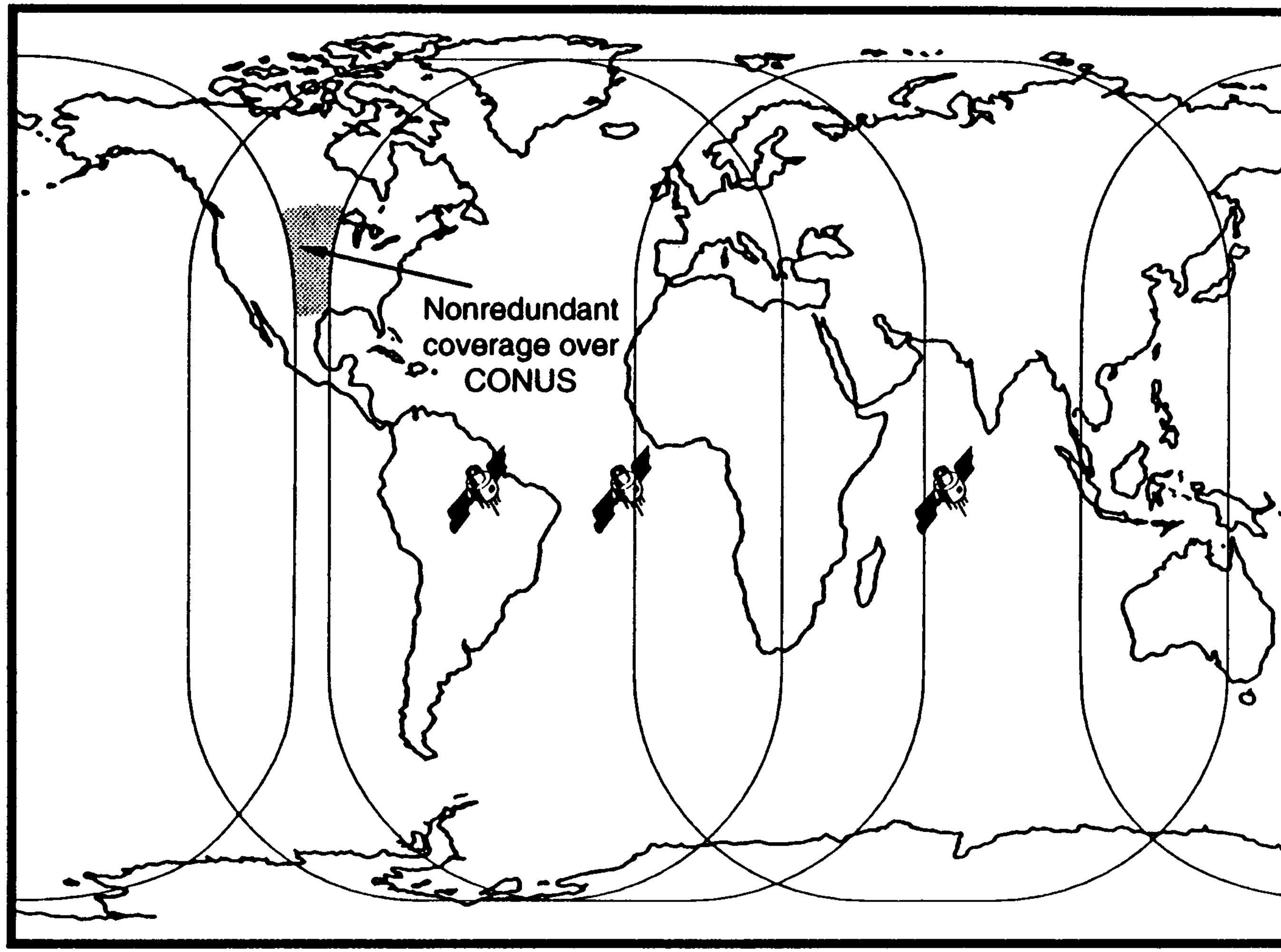

Figure 2. Footprints for the Inmarsat-3 Satellites with a Mask Angle of 5 Degrees

cover CONUS. At this time there are many tens of thousands of general aviation Loran-C receivers, and approximately 10 percent of these are instrument flight rules (IFR) certified. An integrated GPS/Loran-C system will require at least 5 measurements for position determination and at least 6 or 7 for RAIM. However, in CONUS, the combined system will have access to at least 9 and an average of 11 pseudorange measurements.

Integrated GPS/Loran-C has potential as a national RNP system for all phases of flight except precision approach. The target year for FAA supplemental certification of GPS/Loran-C with RAIM is 1993. As experience is gained, by 2000 it could evolve into an RNP system for domestic en route, terminal area and nonprecision approach operations in the U.S.

GPS and GLONASS

The planned GLONASS implementation includes a 24-satellite constellation similar to GPS, except the GLONASS satellites will occupy three orbital planes rather than six as in GPS. It will also have a different signal structure and radio frequency band. GLONASS, like GPS, is scheduled to be operational in 1993. Through cooperative efforts with the FAA and the private sector, integrated GPS/GLONASS prototype avionics are being developed and tested.

A GPS/GLONASS combination providing very high availability for accuracy and integrity has potential for worldwide RNP use for all phases of flight. However, in the presence of selective availability and without differential augmentation, this combination would not meet the accuracy and integrity requirements for precision approach. The Inmarsat GIC implementation discussed above also will contain a provision for broadcasting GLONASS integrity monitoring data. Initially GPS/GLONASS will be used as a supplemental navigation system. As experience is gained, it could evolve into an RNP system for oceanic en route, domestic en route, terminal area and approach operations.

Differential GPS for Precision Approach

As discussed earlier, differential GPS will allow the use of GPS for precision approach operations. The differential GPS corrections will improve vertical total system accuracy so that it is comparable to that achievable from Category I-ILS glide slope. Integrity information is contained in the differential GPS message. Differential corrections could also be applied to GLONASS to provide a GNSS with potential for meeting RNP for Category I operations.

atmospheric, satellite clock bias, and satellite position). Wide-area differential GPS is not as accurate as local-area differential GPS; however, it requires a significantly smaller number of ground sites to derive differential corrections for the many runways in the United Sates that would benefit from a precision approach capability. It may be implemented as an overlay to the GIC. The broadcast of choice for local-area differential GPS is a local terrestrial link such as very high frequency (VHF) or pseudolites (ground-based transmitters with GPS-like signals), and for wide-area differential GPS, satellite links with GPS-like signals in the GPS frequency band.

As noted earlier, the main operational advantage of differential GPS is that it will provide the capability for conducting precision approaches at any runway within its coverage area and may provide runway surface position determination and surveillance. Particularly in conjunction with an inertial reference system, it should be possible to attain Category I accuracy and continuity of service when the satellite geometry provides sufficient GPS accuracy in the vertical direction.* With differential GPS/GLONASS there is also potential to meet accuracy and availability/continuity of service for RNP for Category I or near Category I precision approaches.

In summary, differential GPS will be used for terminal area navigation, precision approach, and may be used for airport surface position determination. Local DGPS use for precision approach, as a supplemental system, for GPS/IRS equipped aircraft is expected to occur by the end of 1994 through private local-area differential service providers. For the target year of 1998, at selected airports, the FAA will begin implementing local-area differential GPS with the data broadcast by pseudolites. If wide-area differential GPS proves feasible, it would be in operation by the target year of 2005 for near CAT I precision approach service.

Implications

Realization of the above vision for satellite navigation has several important implications for the FAA in its role as navigation provider, and raises a number of issues that must be addressed.

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* It is assumed that any use of GPS for precision approach beyond Category I will not be implemented until sufficient experience is obtained. Consequently, this capability is not addressed here.

- **Integration with air traffic control (ATC)**, including: unambiguous position determination for use in communications with ATC; provision of Notices to Airmen (NOTAMs) about GPS signal status; and for oceanic operations, integration with communications for use in automatic dependent surveillance.

- **Coordination with DOD** in areas such as integrity, the number of GPS satellites and their availability, and the application of selective availability (See below).

Since GPS is a new navigation system, there are many issues the FAA plans to address in coordination with the aviation community, and then act upon in a timely manner to meet the previously mentioned target years for the various implementations. The following key issues need to be addressed:

- **Selective availability**--If selective availability still needs to be implemented in the future when there is wide GPS equipage, an agreement needs to be made with DOD to limit its magnitude and rate of change.

- **Performance of RAIM**--The methodology for determining the performance of RAIM needs to be established so that GPS can be used early at its full capability as a supplemental navigation system.

- **GPS Integrity Channel**--The GIC response time needs to be validated, its algorithms need to be developed and validated, its network design needs to be developed, and coordination with Inmarsat and within International Civil Aviation Organization (ICAO) needs to be completed. Also, if an implementation decision is made, other satellite communications service providers must be encouraged to become interested in carrying GIC payloads so that the source of the integrity broadcasts can be redundant and competitive.

- **Avionics Certification**--To meet the target years for the various GPS configurations discussed above, avionics certification procedures for supplemental navigation is projected to be accomplished in 1993. Certification procedures for RNP avionics is projected to be accomplished by 2000. Detailed schedules for FAA certifications for supplemental and RNP equipment are given in the *FAA Satellite Navigation Program Plan, 1992-1997.*

- **GPS/GLONASS**--GPS/GLONASS offers promise for initial establishment of the RNP-GNSS envisioned by ICAO and endorsed by the United Sates. Therefore, FAA procurements for enhancing GPS (e.g., GIC and differential GPS) should allow for growth to accommodate GLONASS.

Finally, a transition plan is needed for evolving to the GNSS as the primary radionavigation system. In this connection, two basic concerns in particular must be addressed:

- **Availability**--the availability of the satellite navigation service must be enhanced. This can be done by implementing avionics augmentations (e.g., inertial reference system) or by adding more satellite navigation signal sources.

- **Integrity**--without augmentation, the percent availability of the integrity of the GPS system is not adequate to provide timely warnings to users when the system should not be used for navigation. Thus the FAA has on going programs to explore both ground-based and airborne autonomous integrity determination.

CONCLUSION

GPS and its various augmentations will greatly enhance navigation services to users over what is available today. Improvements in coverage and accuracy, will yield safety, economic, and convenience benefits to civil aviation users worldwide. Potential required navigation performance is summarized by flight phase in table 1. Figure 3 is a top-level summary of the FAA's projected civil aviation operational implementation of GPS. This implementation arrives in three "waves": GPS as an input to multisensor navigation (currently approved); GPS as a supplemental navigation system (1993); and GPS augmented for required navigation performance (2000). The culmination of this vision will be the GNSS, available globally and continuously to all categories of civil users for all phases of flight (2005). Then the user can expect to obtain complete radionavigation service for all phases of flight with the same receiver.

Table 1. Potential Performance Summary by Flight Phase Augmented f
Required Navigation Performance (RNP)

System	Flight Phase											
	Oceanic			En Route			Terminal			Nonprecision Approach		
	A	I	C	A	I	C	A	I	C	A	I	C
GPS (with altimeter)	●	○	?	●	○	?	●	○	?	●	○	?
GPS (with GIC)	●	●	?	●	●	?	●	●	?	●	●	?
GPS/IRS	●	●	●	●	●	●	●	●	?	●	●	?
GPS/Loran C	●	●	?	●	●	●	●	●	●	●	●	●
GPS/GLONASS	●	●	●	●	●	●	●	●	●	●	●	●
DGPS	F/A			F/A			●	●	?	●	●	?

*Potential for near CAT I

Parameter Code
A Accuracy performance
I Integrity capability
C Coverage/availability
F/A Possible future application

Performance Level
● Adequate
○ Does not have
? Uncertain

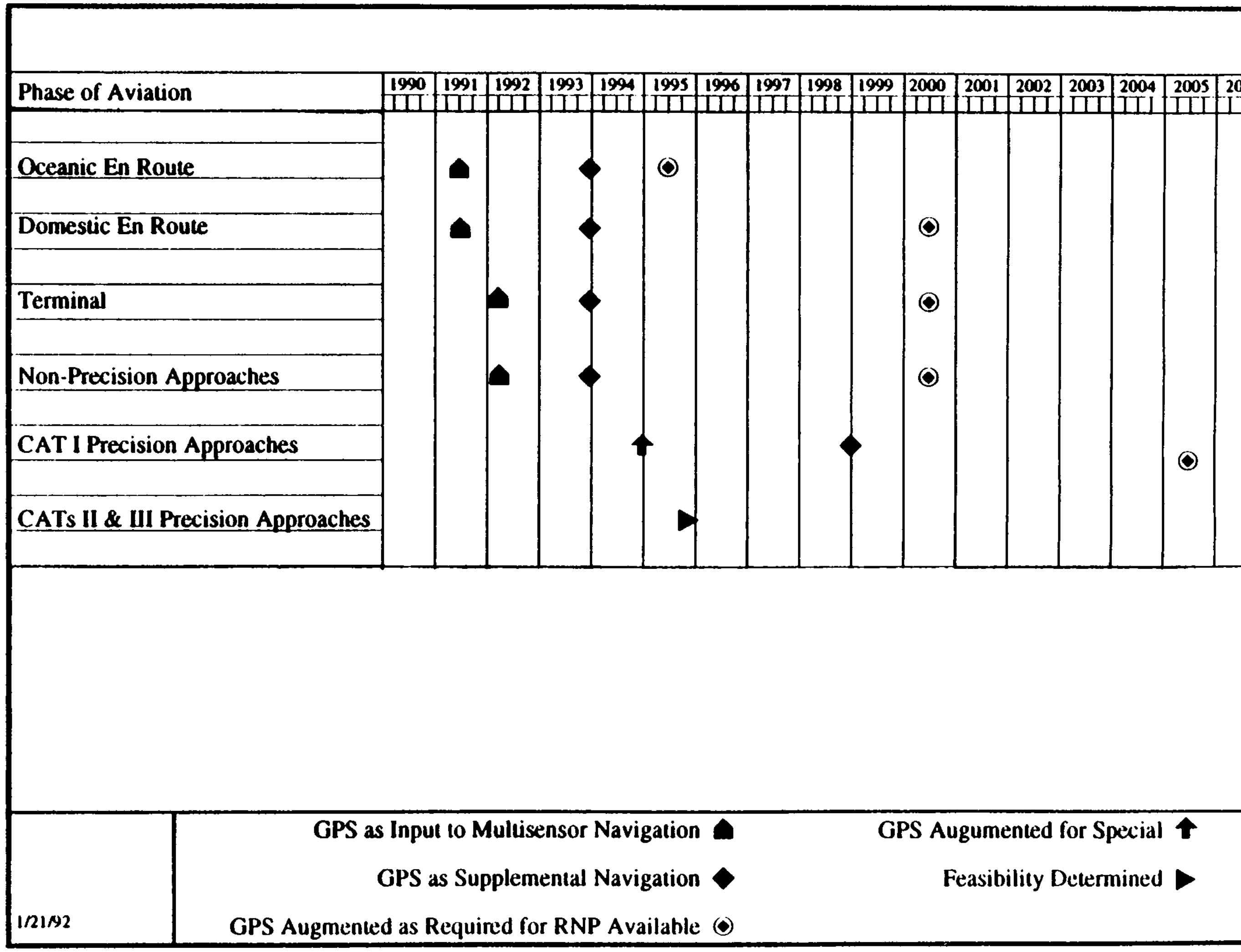


Figure 3. Projected Civil Aviation GPS Operational Implementation Summary

GIC	GPS Integrity Channel
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ICAO	International Civil Aviation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IRS	Inertial Reference System
NAS	National Airspace System
NOTAMs	Notice(s) to Airmen
PPS	Precise Positioning Service
RAIM	Receiver Autonomous Integrity Monitoring
RNP	Required Navigation Performance
SOIT	Satellite Operational Implementation Team
SPS	Standard Positioning Service
TSO	Technical Standard Order
VHF	very high frequency

The current oceanic Air Traffic Control (ATC) system is characterized by manual ATC operations, large separation standards, and cumbersome communications. Each of these factors contributes to the system's limitations. System enhancements are being planned in the areas of communications, navigation, surveillance and automation. These enhancements will provide navigation and communications capabilities that will be equivalent to, and even exceed, those currently available within the US domestic airspace. These enhancements will increase airspace capacity to handle the anticipated growth of traffic in the 21st century. They will also provide the basis to adjust separation standards permitting the use of both lateral and vertical random aircraft routing. This will enable aircraft operators to optimize their flights. Within the international community, industry and airspace users have recognized the need for enhancements and have proceeded with plans for improvements. As stated in FANS II:

> *Preparations are under way for the global implementation of a future air navigation system. This system will provide for cost effective improvements in Communications, Navigation and Surveillance (CNS) and Air Traffic Management (ATM) to accommodate the projected growth and diversity of civil aviation well into the twenty-first century. Global implementation of this system will allow all States to take full advantage of these improvements and provide improved service in their Flight Information Regions (FIRs).*[1]

The purpose of this paper is to provide a future oceanic vision which can be used to clarify proposed concepts and plans and to obtain a consensus view of oceanic airspace users and managers regarding: the operational philosophy and functions of the future system; the priorities of various improvements; and a common timetable to implement these improvements. It will also serve as a road map for global transition to the FANS concept for CNS-based oceanic air traffic services.

1.1 SCOPE

This paper presents an overall vision for Oceanic Air Traffic Control in the 2010 time frame. Concerns unique to the individual Air Traffic Control Centers responsible for Oceanic Air Traffic Control are not addressed except as they relate to generic oceanic operations. Although they are important, operations related to Houston, responsible for the Gulf of Mexico, and Honolulu are not covered in this document, since descriptions of these unique operations would tend to dilute the central theme. This paper also deals primarily with the operational aspects of

2.0 THE PRESENT OCEANIC SYSTEM

A brief review of how oceanic air traffic control has operated in the past and a discussion of its limitations is a necessary first step in the development of a future concept. Although automation is being introduced into a number of centers, the manual procedures described below have been typical of oceanic centers worldwide. Therefore, the assumed level of ATC automation in this discussion is limited to flight strip printing and transmission by teletype of position reports and clearance amendment requests.

2.1 Present Operations

Figure 1 illustrates the basic features of the current oceanic system. Communications over the ocean are performed via HF radio messages between the aircraft and a communications provider. These messages are then relayed to the oceanic center by teletype. Voice communications from ATC to the aircraft utilize a similar relay. The controller monitors the positions of aircraft in his sector using flight strips derived from aircraft flight plans, updated by the position reports that are sent at approximately each 10^{o} of longitude. Each reporting position, or waypoint, requires one flight progress strip on the controller's flight strip bay. The majority of high density oceanic traffic uses a track structure which cannot easily accommodate user preferred routes and flight profiles. Tracks are routes defined by waypoints and can be fixed routes that are published, or flexible routes that are determined on a daily basis and disseminated to the air carriers. Although some variations exist, these procedures are typical of oceanic centers worldwide.

The majority of aircraft enter oceanic airspace from controlled airspace, with transfer of control coordinated by the transferring (adjacent) facility. Prior to this, the pilot must receive and verify his flight plan which is generally accomplished by VHF voice communication. An aircraft entering from uncontrolled airspace will usually obtain its oceanic clearance in the same way as it would at a transition waypoint on its route of flight. Typically, oceanic controllers do not have the means for advance planning of traffic flows before the aircraft reach oceanic airspace. During peak hours, a large amount of traffic must be funneled into a small set of oceanic routes. Traffic leaving coastal airports may be delayed, rerouted to a parallel track, or given less-preferred altitudes in order to accommodate these large flows.

2.2 Typical Flight Scenario In Current Oceanic System

An example of a typical transoceanic flight today illustrates the operation of the current system. This example represents a flight across the Pacific and is depicted in Figure 2.

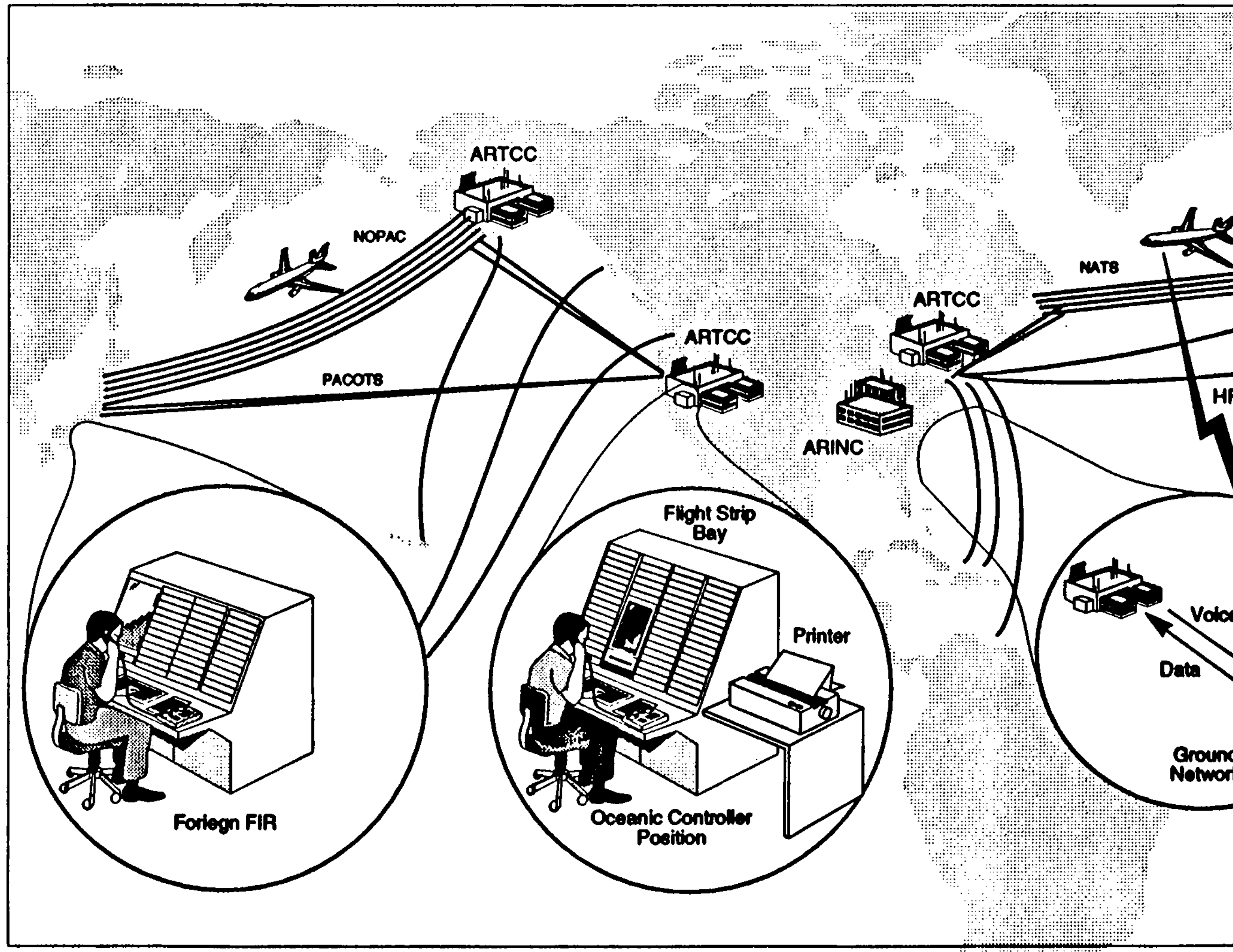


Figure 1. Current Oceanic System

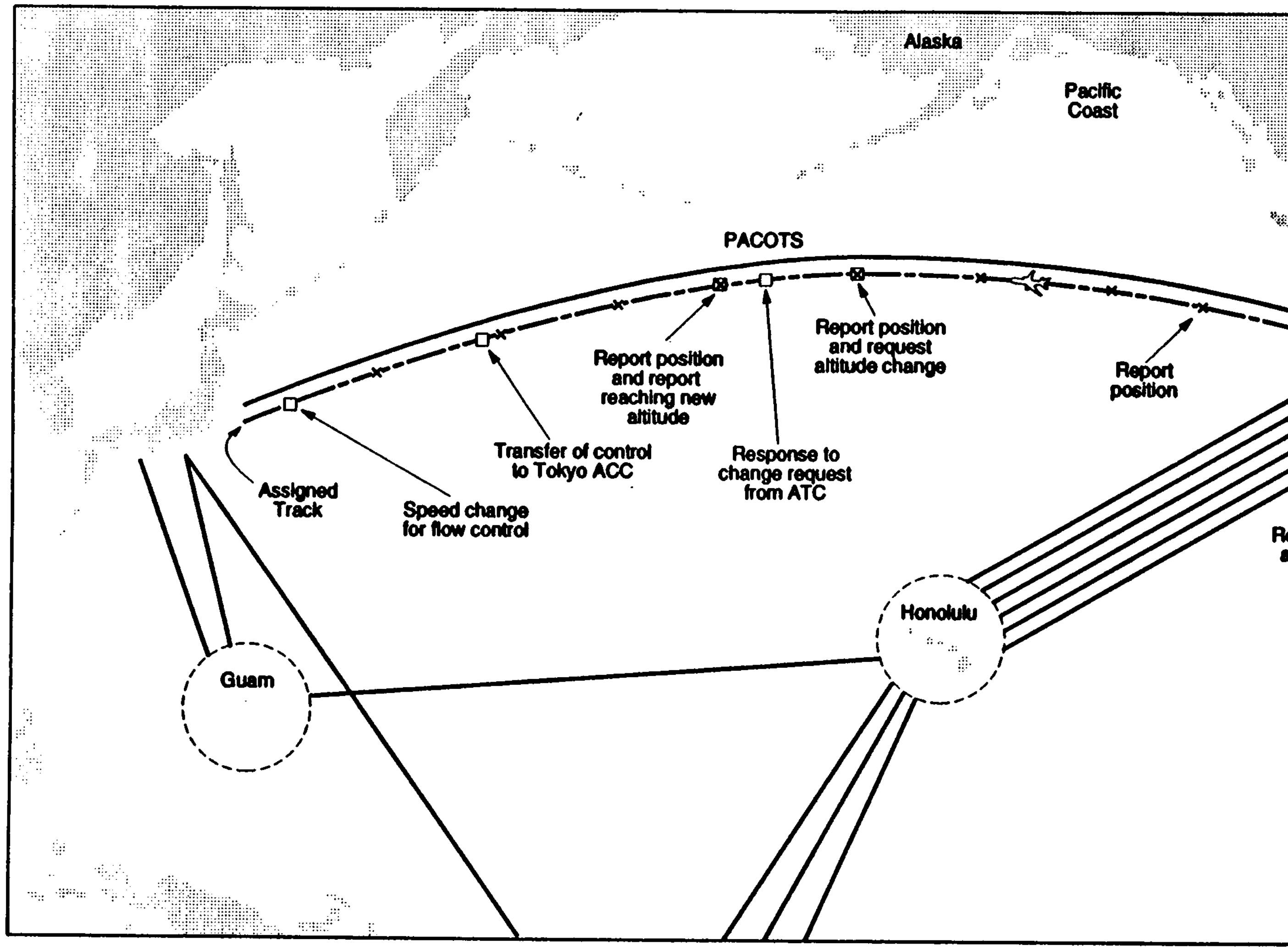


Figure 2. Typical Transoceanic Flight In Today's Environment

flight operations determines which track to use and develops a flight plan which is given to the pilot. The completed flight plan is then entered into the domestic air traffic control system. Approximately one hour before entry into oceanic airspace, the flight plan is transferred from the domestic system to the oceanic automation system. At this point, the flight plan is assessed by the controller for potential conflicts. If a problem exists for the flight plan with other traffic, negotiations will occur between the oceanic entry sector and the domestic transitional sector. This negotiation is performed via voice between the two sectors. Efforts are made to resolve the potential problem by changing the flight plan. The changes are made to the aircraft's route while it is still within radar coverage and before its entry into oceanic airspace.

The pilot sends position reports during the flight at specified reporting points approximately 45 minutes apart at 10° longitude crossings. These reports are sent by HF voice to the communication service provider, who in turn transcribes the reports for relay via teletype to the controller. The controller records this position information on paper flight strips in order to follow the progress of the flight. The controller then mentally monitors the aircraft's conformance to the agreed flight plan.

As the aircraft burns fuel and becomes lighter, it is more fuel efficient to fly at higher altitudes. The pilot then attempts to communicate with the communications service provider to make a request for a higher flight level. In doing so, the pilot may have to wait for radio traffic to subside, before a clear connection is achieved. In some cases, the propagation characteristics of HF communications create unintelligible messages that require repeating or relay through another aircraft that may have a better ground connection. The request for altitude change may or may not be granted by air traffic control depending on the traffic situation. Nonetheless, after the controller processes and assesses the request, the controller's response is sent back to the communications service provider and then by voice to the pilot.

At some pre-specified time before crossing a boundary between FIRs, the controller will coordinate the handoff process by providing the aircraft's intended route of flight to the adjacent facility. This exchange of route and coordination information occurs via telephone. The receiving FIR also records the information on flight strips to monitor conformance and ensure separation. As a result of the coordination, the flight plan may be changed to incorporate it into the traffic of the new FIR, similar to the changes coordinated between domestic and oceanic sectors. The new clearance is relayed to the aircraft, again via the communications service provider, manually input into the on-board flight management computer, and verified by voice read-back to the controller via the communications service provider. At the point of be necessary and will be handled by the same voice communications and manual techniques as described above. The merging process uses gateway fixes to integrate traffic into the domestic flow. At this point the aircraft is again within radar coverage and direct communication with air traffic control is established.

3.0 Limitations Of The Present System

Because of the limitations of the present oceanic system, oceanic airspace users are frequently unable to achieve maximum fuel efficiency, minimum travel times, preferred takeoff times, and flight paths that are free of severe turbulence. As oceanic traffic levels increase in the future, producing more airspace congestion and more demand on ATC and communications, it will become even more difficult for each airspace user to achieve these goals. Projections indicate a possible overall increase in North Atlantic traffic of about 50% between the years 1990 and 2000 and an increase in Pacific traffic from the U.S. of about 100% during that same period. Oceanic system capacity limits how many aircraft are able to fly on the most desirable routes. Thus, fuel efficiency, trip duration, ground delays and the ability to avoid adverse meteorological conditions are all dependent on system capacity. Currently, some of the major constraints on oceanic system capacity are: communications capabilities, ATC system capacities, and current airspace capacities.

The number of aircraft operating in an airspace may be large enough that the HF voice link becomes congested and it is difficult to convey a message. Messages may be significantly delayed or lost. Since surveillance is dependent upon air/ground communications, surveillance can be degraded by HF congestion. Thus, air/ground communications capability limits the number of aircraft that can be safely accommodated, and also affects the number of flight plan changes that can be requested and cleared by ATC.

ATC system capacity refers to the amount of traffic that can be safely handled by a given air traffic control sector or facility. ATC system capacity is closely related to controller workload and automation processing capability. Additionally, the ATC system's ability to estimate current aircraft positions, predict future conflicts, and issue instructions to maintain separation are all parameters affecting ATC system capacity. These parameters are also affected by communication, navigation and surveillance capabilities. Generally, if controllers working a sector cannot accept the increased workload associated with an additional aircraft due to constraints, or if controllers decline to clear aircraft to new altitudes because their workload does not permit, the ATC system limit has been reached.

and surveillance which do not provide the ability to detect and correct blunders in a timely manner. The key to achieving tangible benefits for the airspace user through increased ATC system capacity lies in the reduction of these separation standards. In order to realize a reduction in oceanic separation standards, substantial improvements need to be made in the system infrastructure, especially communication and surveillance.[2]

4.0 OCEANIC ATC SYSTEM GOALS

The objectives of oceanic ATC can be classified into two broad categories: user needs and operator needs. The users want to be able to fly when and where they desire (User Preferred Trajectories, or UPT's) and they want to experience minimal and equitable delays or deviations when they can't. The oceanic system operators need to be able to handle the demand on the system, and increase productivity, while maintaining safety. To be able to assess whether the oceanic ATC system is meeting these objectives as it evolves, goals should be set by which our progress can be gauged.

To meet the needs of the user, the oceanic system must have the capacity to support the number of flights expected. Therefore, one goal of the future oceanic system is to accommodate a possible four fold increase in demand by 2010 without a degradation of service or safety. For example, if the projected growth rate in oceanic traffic for the transpacific routes in the 1995-2000 time frame continues through the year 2010, Oakland center will have to deal with almost 750 thousand flights a year, or an average of 2000 flights a day compared to approximately 550 flights per day at present.

Capacity of the system is intimately tied to the allowed separation minima of the system. Another goal of the system is to reduce separation minima to values equivalent to those used in present domestic airspace. Some of the present oceanic separation minima are time based, commonly 10 minute minimum separation in trail. This equates to a distance on the order of 80nm. As described in section 5, modern navigation systems will allow position accuracies better than that achieved by radar in present domestic airspace. This, coupled with communications timeliness supplied by satellite communication (SATCOMM) and automation aids available to the controllers and pilots, support the adoption of a goal of separation of aircraft by a 30nm lateral and 5minute longitudinal standard without decreasing present safety margins.

The reduction of communication delays is another goal. For the controller to be able to effectively interact in the future oceanic system with its reduced separation minima and increased aircraft density, communications delays will need to be reduced from tens of minutes to fractions of minutes in the future oceanic system.

Another goal of the oceanic system is to be able to grant a majority of all user preferred trajectories, both in space and time. This would apply to requests made preflight as well as en route. Delays in responding to requests will be no more than a few minutes. Variations between requested and granted flight profiles due to conflict between users will be equitably distributed.

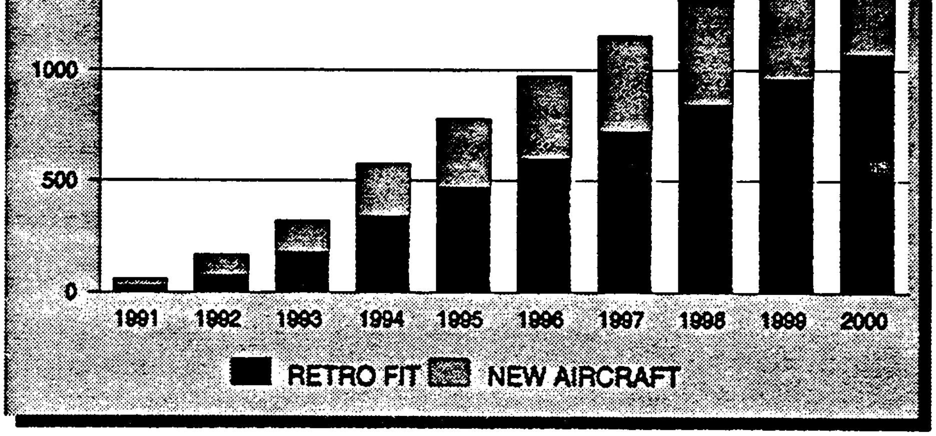
5.0 THE IMPACT OF ADVANCED TECHNOLOGY ON OCEANIC OPERATIONS

The ability of the oceanic system to achieve the above goals will be heavily dependent on the availability of accurate navigation and timely communications. The following are the key technologies that will provide these capabilities.

5.1 Satellite CNS

> *Satellites for data link communications and surveillance systems are currently available. Their capacity will expand by a factor of 3 in the mid 1990's, a factor of 10 by the year 2000, and a factor of 30 by the year 2010. Aircraft equipage for satellite communications is estimated to be at a level of 250 aircraft by the end of 1992, 3500 aircraft around the year 2000, and 8,000 aircraft by the end of the next decade. Aircraft equipage for VHF data link communications is estimated to be at a level of 4,700 aircraft by the mid 90's.*[1]

The availability of satellite-based communications, navigation and surveillance (CNS) for oceanic air transport provides a capability for advanced air traffic management which would otherwise not exist. The key element, satellite communications, is already a reality for a number of airlines and, as shown in Figure 3, the projected growth in equipage should reach several hundred by mid-decade. It is also interesting to note that a significant percentage of these are existing aircraft that will be retrofitted with satellite communications avionics. Several national and international trials of Data Link communications and Automatic Dependent Surveillance (ADS) have already been conducted and a limited, operational use of Data Link for waypoint reporting in lieu of voice position reports for oceanic ATC has been authorized by the U.S. Federal Aviation Administration (FAA).



Source: Aeronautical Radio, Inc. October 1991

Figure 3. Oceanic Air Traffic Environment Changes

Satellite navigation will provide extremely accurate position estimates. For example, the U.S. Global Positioning System (GPS) will provide a worldwide horizontal positioning error of less than or equal to 100 meters 95 percent of the time and of less than or equal to 300 meters 99.99 percent of the time. The corresponding vertical positioning errors will be 156 meters and 468 meters. This level of performance will permit ADS position determination with an accuracy superior to terrestrial radar.[3]

Satellite-based CNS for oceanic ATC also provides the prospects for immediate communications between pilot and controller and frequent position reports. It should be noted that the primary mode of communications will utilize data link ATC messages with voice communications reserved for a back-up role. The enormous improvement in ATC capabilities provided by CNS, taken together with the automation capabilities which will reside in both the aircraft and control center provide the means for revolutionary improvement of oceanic ATC.

Today, SATCOMM capabilities are expensive, both in terms of equipment and on a per message basis. Satellite communication for aircraft are presently provided by International Maritime Satellite (INMARSAT), which was originally set up in 1982 to coordinate and operate SATCOMMs for ocean going shipping. Additional satellite communications carriers, however, will be available in the near future. Agreements reached at the World Administration Radio Conference (WARC-92) in Torremolinos, Spain allocated frequencies for Low Earth Orbit (LEO) satellite systems for global voice or data communications. A number of

5.2 Aeronautical Telecommunications Network

In the air-ground data link communications of the future, satellite data link will be interoperable with VHF and Mode S data links. This will be accomplished using a new communications architecture, the Aeronautical Telecommunications Network (ATN), which has been developed for this purpose. The ATN will permit data link communications to transition from satellite to Mode S or VHF data link (and possibly HF data link) in a manner which is transparent to both the pilot and controller.

Presently information flows between the controller and the pilot or between the pilot and the airline operations centers. The ATN will allow the information to flow between the pilot, controller and operations center in a three way exchange, routing the data through the best path available.

5.3 Automation in the Cockpit

The Flight Management Systems (FMSs) of many of today's air transport aircraft provide a real-time capability for optimizing the aircraft's route and altitude profile which is currently unmatched in the ATC centers. With the introduction of satellite data link and comparable automation facilities on the ground, the prospect of an automated air-ground dialogue between these systems, monitored and controlled by the pilot, airlines operation center, and controller, is quite likely. Data link communications between nearest neighbor aircraft will also be possible using VHF data link capabilities. These may include passing of wind and weather information, backup relay of data link messages where an aircraft's SATCOMM equipment has failed, and situational information as to position and intent of neighboring aircraft.

This flood of information will require new capabilities in the cockpit to summarize and display this data. The future cockpit will utilize advanced display technology, such as flat panel displays and synthesized voice, for information output. Future systems may also employ Heads Up Displays (HUDs) to minimize the time the pilot is distracted from visually observing the aircrafts surroundings. Cockpit systems will be integrated though the Flight Management System (FMS) with aircraft navigation, flight controls, and communication systems. Tactical and strategic information will be provided to the flight crew in both graphic and in textual formats.

Data inputs to the on-board systems will utilize touch screens and voice recognition in addition to standard keyboards. Automated message generation will be available for the transmission of standard data link messages. Information received via data link will be used to update the FMS automatically when commanded by the pilot.

management computer operations via data link. These new capabilities will permit flexible routing and dynamic modifications to aircraft routes in response to changes in weather and traffic conditions. The basic elements of the future oceanic system are described in the following sections: airspace usage, air traffic management, and air traffic control.

6.1 Airspace Usage

While safety is of paramount importance, flexibility in the use of airspace is needed to ensure that all users gain maximum economy of operations with minimum constraint. Traffic growth and dramatic increases in user fuel cost serve to highlight the need for integrated, multinational route structures and control systems that are responsive to user efficiency needs. Fixed routes in today's system are utilized where high density flows exist. These routes are being replaced by flexible tracks to better respond to changing conditions. The future system will be able to respond to changing weather and traffic dynamically. When traffic volumes are low, aircraft will fly user preferred trajectories with minimal constraints. When traffic volumes increase in a particular region and at a specific time, airspace volumes or skyways will be dynamically developed to suit the particular conditions and traffic flow. These routes will take into account the traffic mix by type of aircraft and equipage and will provide preferred routings to aircraft meeting minimum performance requirements for navigation accuracy, surveillance and communications.

As shown in Figure 4, the rigid track system will be replaced by a system in which optimum routes are given within defined volumes of airspace. Aircraft meeting the minimum system capabilities for CNS, referred to as Required System Performance (RSP), will be able to obtain fuel optimum profiles. Within the preferred airspace, separation standards will be reduced to increase the effective capacity of the airspace. This will be possible with no reduction in safety because of the capability for intervention provided by satellite CNS. Aircraft having a lesser level of capability will be allocated airspace and utilize separation minima appropriate to their level of performance. Because of the increased capacity available in airspace used for aircraft with the highest level of CNS capability, the proposed airspace restructuring will not have a negative impact on lesser equipped aircraft. These aircraft will benefit from reduced demand on their airspace due to the absence of the satellite equipped aircraft.

6.2 Air Traffic Management

The general objective of ATM is to enable aircraft operators to meet their planned times of departure and arrival and adhere to their preferred flight

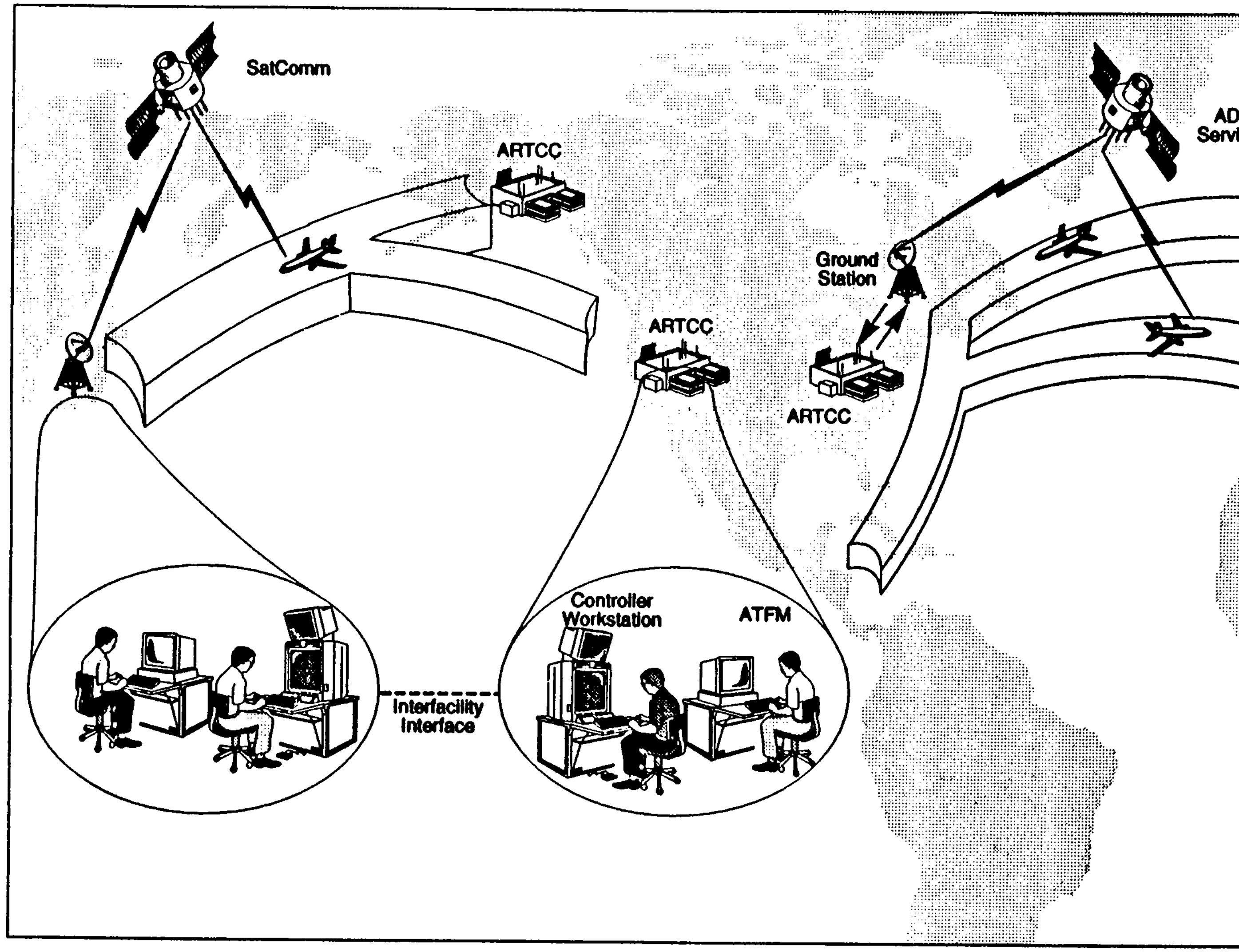


Figure 4. Future Oceanic System

trajectory. The ability to accurately monitor the real-time oceanic traffic will enable domestic traffic management to effectively coordinate with oceanic traffic management ultimately combining these two activities into one operation.

Combining modern techniques for flight planning and profile generation along with accurate weather prediction and increased situation awareness will allow for the creation of a four dimensional (4D) flight plan. This 4D flight plan will utilize the most efficient flight path available and address the user's requirements from the start. The flight planning process will become a more dynamic exchange between the airspace manager and the airlines. Information will be shared through a common network so that all affected centers and FIRs will have positions and relevant information on all aircraft.

Air Traffic Flow Management (ATFM) services try *to ensure an optimum flow of air traffic to or through areas during times when demand exceeds or is expected to exceed the available capacity of the ATC system.*[4] Airspace management's goal is *to maximize, within a given airspace structure, the utilization of available airspace by dynamic time-sharing and, at times, segregation of airspace among various categories of users based on short-term needs.*[4] Best use of the airspace and airports capacities requires an efficient airspace structure which permits planning in the aircraft and in the ATM system. The airspace structure must also accommodate the capabilities and desires of the airspace users and utilize data available in the aircraft. Even though the future system will have increased capacity, there will still be competition by the users for desirable routes and times.

ATM activities will not stop with the acceptance of a flight plan. With the receipt of real-time wind and flight progress data comes the ability to dynamically alter flight plans based upon the actual performance of the aircraft and the status of the airspace in which it is flying. Changes will be based on both the strategic and tactical traffic situation. The use of advanced CNS techniques will permit a greater flexibility in ATM. Potential conflicts can be avoided and weather-induced routings modified for en route aircraft due to the accurate position information available and the capacity for timely intervention afforded to the controller.

The ability to estimate aircraft performance along a route due to weather conditions will derive from the capability to accurately predict weather conditions, in particular, wind speed and direction. The traffic control and traffic management automation will utilize accurate winds aloft data for performance assessment, flight plan conformance monitoring, and conflict detection and resolution. Weather prediction will also allow the planning of routes around areas

Common information databases, such as traffic conditions and weather, will enhance the flight path optimization process by permitting user involvement in the decision making process. The common weather database will include a high resolution grid of weather data updated by wind and temperature reports from CNS-capable oceanic aircraft.[5]

Oceanic centers may or may not be consolidated in the future. The general objective of ATM is to enable aircraft operators to meet their planned times of departure and arrival and adhere to their preferred flight profiles with minimal constraints without compromising agreed levels of safety. *Systems integration will not necessarily imply consolidation of air traffic service units or flight information regions.*[4] The boundaries between them will be virtually invisible (or seamless) to the users and traffic management systems will be globally linked. The Tenth Air Navigation Conference (ANC) stated one goal of the future ATM system is *to create, to the maximum extent possible, a single continuum of airspace, where boundaries are transparent to users.*[6] Centers will interact via computer-to-computer links, providing essentially instantaneous information on any aircraft, route or segment within the global oceanic system. Within the U.S., there will be at least two major control facilities, covering the Pacific and Atlantic, which will be able to provide backup processing for each other. This allows redundant systems for the global network.

6.3 Air Traffic Control

> *The main objectives of the ATC service are to prevent collisions between aircraft and between aircraft and obstructions on the maneuvering area and to expedite and maintain an orderly flow of air traffic.*[4]

Advanced automation and widespread satellite equipage will enable conflict-free, four dimensional air traffic control. Computer-to-computer transactions will be monitored by both pilot and controller and will provide checks between aircraft and controlling facility for flight plan conformance. Automation systems will recognize and support dynamic four dimensional flight profiles. This support will include continuous separation assurance monitoring. Aircraft intent will be presented to the controller in a form that does not require a track system to visualize.

General principles and philosophies associated with controlling aircraft will change. First, aircraft will be separated from aircraft using more accurate, reliable, error-free, real-time information. Therefore, the need to provide buffered airspace around aircraft in addition to the current large separation standards will not be necessary. Secondly, increased situation awareness by both pilot and controller, accurate real-time position information, weather data, airspace. Controllers, assisted by their automation aids, will be responsible for resolving conflicts at the tactical level (one-on-one situations) and preemptively by adjusting flows where congestion is predicted in the airspace. Controllers will operate interactively with the ATFM personnel to maximize the efficiency of the airspace utilization.

Air traffic controllers will utilize high resolution, graphical situation displays to assist in planning, as well as evaluating specific resolution strategies for an identified conflict. Flight strips will be replaced with an electronic tabulation, allowing frequent updates, more data and easier manipulation. Conflicts will be detected through use of the automation and possible resolutions will be presented to the controller. The same information or resolution choices may be presented to a pilot for review and selection so that flexibility and efficiency of flights are maintained. Reliable and immediate data communications with pilots will allow pilot participation in the negotiation of any deviation from the flight plan. Dependent surveillance functions will be automated, and coupled with FMS navigation capabilities, will provide a level of position certainty over the ocean never before achieved.

Air traffic control facilities will interface via computer-to-computer links allowing automated exchange of flight plans for coordination and transfer. *Each contracting State, acting in concert with adjacent States and with the ICAO regional and international bodies, will ensure that the benefits of the new system concept will be achieved by all in a timely and cost-effective manner, and in accordance with their individual needs.*[1] The future system will have all of a region's oceanic air traffic controllers and flight crews linked electronically. Air traffic management service providers will be able to meet their traffic demands in a globally integrated manner, consistent with their own objectives. They will have capabilities that are presently not practical or economically feasible. The result will be improvements in operational efficiency and control.

Workload planning functions will be used to estimate and balance controller workload within a given FIR. The functions will provide the planning supervisor with information on traffic and airspace conditions as they are forecast to exist at some time in the future. The reduction and balancing of controller workloads will derive from three factors: reduced number of potential conflicts, reduced number of amendment requests needed, and more evenly distributed sector loading. First, since the strategic ATM function will have the capability of providing conflict-free routing for random flight plans, there should be fewer potential conflicts that will arise en route. Second, since the flight plans which were initially cleared should take into control system will be provided within the cockpit. This will include a cockpit display of proximate aircraft showing the bearing, range, and relative altitude of each. This display will assist the flight crew in visually acquiring proximate aircraft so that the crew can maintain visual separation (i.e., the display assists the crew in their responsibility to see and avoid other aircraft) as well as alert the pilot to intruders during instrument conditions. Additionally, conflict resolutions will be displayed for those aircraft in close proximity providing resolution options in both the vertical and horizontal planes. This information, in turn, may be shared with the controller so that the option chosen will be known by ATC as quickly as possible. A shared information system such as this will provide increased flexibility and situation awareness in future scenarios.[7]

7.0 FLIGHT SCENARIO IN THE FUTURE SYSTEM

The future oceanic system can be further illustrated by once again look at a typical flight across the Pacific Ocean. The comparison of this example to that previously described highlights the benefits of the future system features. Figure 5 depicts the envisioned airspace, along with the major activities of the flight in the following scenario.

No tracks need be generated in the future system as there will be volumes of airspace allocated for suitably equipped aircraft. A four dimensional flight plan, including altitude changes for fuel efficiency, will be filed by the airline. The route and plan will be checked and entered into the en route, oceanic and adjacent FIR automation systems simultaneously. The information will be passed electronically among these and the airline operations centers for ease of negotiation and automatic checking. Flight plans will be used for traffic management and strategic planning purposes. By informing the airline of airspace availability, a flight plan can be negotiated that will be close to the optimum route requested by the user. A valid, end-to-end flight plan will then be entered into the system. No separate oceanic clearance procedure will be necessary, computer-to-computer verification of the data will ensure consistency.

Position reports will be communicated automatically via a satellite data link to the ground controllers at an agreed-to regular interval. The rate of reporting will be variable, depending on the particular circumstance, but the accuracy of navigation and flight management systems and short communication times will allow low rates when the aircraft is not maneuvering. The position reports will contain both the present position of the aircraft and the predicted future trajectory as calculated by the FMS computer. Automation within the control facility will check

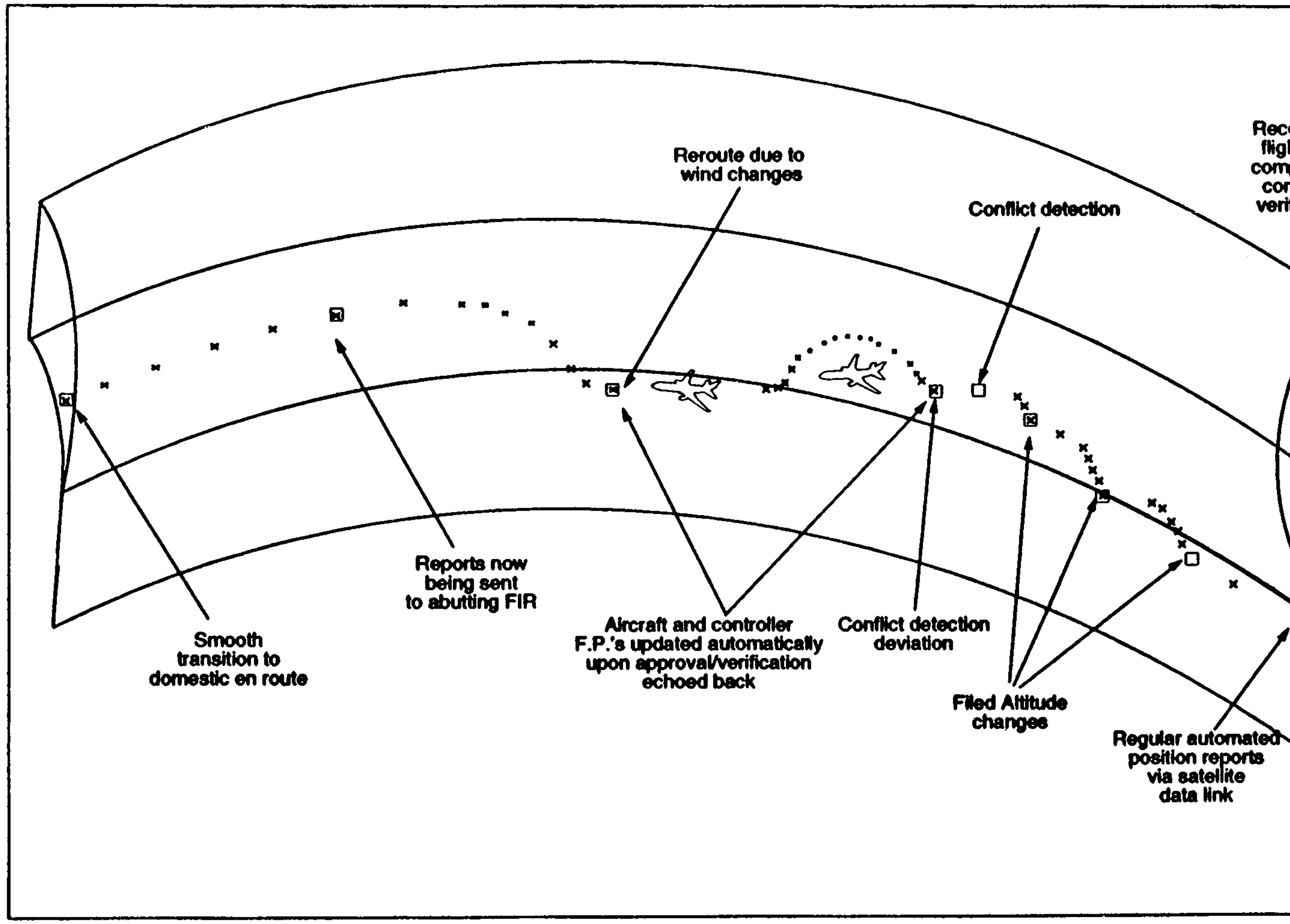


Figure 5. Typical Transoceanic Flight in the Future

optimize a flight path based upon real-time wind information and aircraft performance, or to reoptimize a flight plan due to airspace availability, the controller will utilize the automation system to check the proposed route for potential conflicts. Once checked, the approved change will be sent via data link to the on-board FMS computer. The on-board flight management system will be updated and a verification will be sent back. Thus, the aircraft will be able to avoid turbulence and improve performance while maintaining flight safety and coordination with controllers.

At the point of transition to the abutting FIR, no formal coordination will be necessary. The new FIR will already have the current flight plan available within its automation system. The flight plan will have been accepted and the aircraft cleared for entry into the new region. Position reports will then be addressed to the new ground control facility. The reporting rate may change based on the agreement with the facility. Nonetheless, the change will be transparent to the pilot. Since the other facilities will also have the high levels of automation support for air traffic control envisioned for all major oceanic centers, the same automated coordination is available for the transition to the local domestic traffic. Traffic will be merged with the domestic flow at random crossing points rather than gateway fixes. Thus, it can be anticipated that the user will have been able to fly a fuel and time efficient route, without the constraint of an assigned track.

8.0 Transition

> *The development of the ATM system must be evolutionary. There is often the temptation to design on a clean sheet of paper to take full advantage of new capabilities which new technology offers. The reality is that transition and integration are the most difficult institutional problems facing ATM system designers. The ATM system must accommodate a broad community of users and various levels of avionics equipage. User categories include single-engine, single-pilot, general aviation aircraft, sophisticated business aircraft, helicopters, the whole range of commercial aircraft operating in a variety of environments, and military aircraft of all types. In the future, advanced subsonic transports, second-generation supersonic transports and hypersonic aircraft will be added to the environment.*[4]

The vision that has been described in this paper must be reached in an evolutionary, not a revolutionary, manner. Changes in airspace usage will depend on the rate of equipage of aircraft with the necessary technologies and the implementation of complementary automation automated flight progress monitoring. Paper flight progress strips will still be used in the near term to monitor aircraft performance. OAS will provide for data checking, computed time of arrival updates based on improved wind data, and automatic conflict detection. The Oceanic Planning Tool (OPT) will be used to generate flexible tracks based upon the forecasted winds.

Within the same timeframe, aircraft in the oceanic domain will increasingly make use of satellite navigation. The use of the U.S. Global Positioning System (GPS) and/or the Soviet Union's GLONASS, within the framework of the Global Navigation Satellite System (GNSS) supported by FANS, should be well established by the mid-1990's. Initial use of satellite navigation will be in conjunction with established sole means systems such as OMEGA and Inertial Reference System (IRS).

The first evolutionary step will see the inclusion of ADS capabilities, two way data link and SATCOMM voice. Advanced displays will be implemented for the controllers and, together with new automation capabilities, will allow an improvement in controller workload at peak times. GNSS will be in use for supplemental navigation. Communications capabilities to foreign FIRs will be improved with messages being transferred between automation systems instead of voice and teletype when the other FIR is similarly equipped.

These improvements will provide position reporting at rates 10 times higher than at present. With increased situation awareness and the ability of the controller and pilot to quickly communicate, the controller will now be able to intervene tactically in many situations. The data link capabilities will reduce voice congestion as well as reduce communications errors. At this point separation standards will be reduced for those aircraft that are properly equipped and the ability to grant preferred routes will be improved.

The second evolutionary step will see the introduction of the Advanced Automation System (AAS) Common Consoles into the OAS with the replacement of paper flight strips by electronic flight strips. More aircraft will have equipped with improved CNS. Automated conflict resolution capabilities will be introduced. On-line data exchange with foreign FIRs will increase as other CAAs automate their oceanic facilities. Initial integration of oceanic traffic management into the overall traffic management system will be accomplished.

Separation standards will be further reduced in this step. The automation of manual functions will allow a further reduction in controller workload. Interactive flight planning, and dynamic routing capabilities will be possible due to the increased communications and automation as sole source navigation and the implementation of the Oceanic AAS. Fleet upgrades, as older aircraft are retired, will make the preponderance of the aircarrier fleets ADS and SATCOMM equipped. Separation standards will be aircraft-to-aircraft instead of airspace-to-airspace. Oceanic traffic management will be totally integrated with domestic traffic management. ATFM capabilities, such as dynamic preferred routing, will be a reality.

In the latter half of the decade, the skyway concept will become a reality. Free flight of aircraft will be commonplace over the ocean. Integration between US domestic operations, oceanic operations and other CAAs and their oceanic operations will create a truly worldwide air traffic management system.

3. Report of the Future System Design Working Group, FAA, November 1990.

4. Report of the Second Meeting of the ICAO Special Committee for the Monitoring and Coordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II), Montreal, 29 April - 17 May 1991.

5. The Future of Oceanic Air Traffic Management, Clyde Miller, FAA, ARD-20, October 1990.

6. Report of the Tenth Air Navigation Conference (1991), Montreal, 5 - 20 September 1991.

7. Future Management of Oceanic Air Traffic, Clyde Miller and Joseph Fee, Avionics, August 1991, pp. 37-43.

data-rich, gridded observation and forecast system that will make it possible to deal with weather situations strategically rather than reactively, as is the case today. The accurate, high-resolution weather products provided by this system will be presented to pilots, controllers, and other users in clear, simplified formats on user-friendly displays. The result will be a major enhancement of the safety, efficiency, and capacity of the National Airspace System.

INTRODUCTION

Aircraft and weather have been inseparably linked since the first day of powered flight at Kitty Hawk. Despite decades of technological advances, weather remains one of the most important factors affecting aviation safety and efficiency. From 1970 to 1985, for example, 40 percent of all airline accidents were weather related. Sixty-five percent of annual air traffic control system delays are attributable to weather and account for $1.7 billion of direct costs to the airline industry each year—not including the inconvenience and costs suffered by the traveling public. With aviation demand and business costs projected to double within 20 years, weather-related delays will increase unless avoidable weather-related delays are identified and weather system improvements are planned and implemented.

Unfortunately, the quality of aviation weather services in the United States has major deficiencies, many existing since the 1950s or up to about five years ago when selected improvements were implemented. Today's aviation weather system is characterized by observations that are too sparse, prohibiting the creation of high-quality, definitive, and reliable weather information. This insufficient or inaccurate weather information compromises safety (when pilots inadvertently get into hazardous situations) and efficiency (as they make unnecessary, costly flight path diversions). The lack of adequate predictions about wind and weather conditions that lie ahead results in reactive operational decision making by pilots and controllers.

A much-improved aviation weather system is needed to resolve hazardous and operationally significant weather and make useful products available to ground crews, flight crews, and the automation system. Groundwork has already begun, as U.S. institutions responsible for improving weather forecasting have concluded that higher resolution observations and numerical prediction computer models are necessary. For example, knowledge to detect and predict one of the severest, smallest, and most deadly weather phenomena—the microburst—was virtually unavailable a decade ago. The experimental use of integrated weather sensors, including the Terminal Doppler Weather Radar, at Denver Stapleton International Airport to detect and track microbursts has been credited with saving hundreds of airline passenger and crew lives.

By anticipating a time when improved weather sensors, processors, and much more usable products will become available, the aviation weather system infrastructure has undergone an evolution these shortfalls. They are:

1. To improve the timeliness and accuracy of weather information so that pilots are not forced to "guess" about weather conditions and potentially compromise the safety of passengers and crew.

2. To provide controllers and traffic management with accurate weather information about current and forecasted conditions to support the controllers' responsibility to ensure pilots' ability to make timely and informed operational decisions in response to hazardous weather conditions. In addition, controllers and traffic managers will be able to do a much better job of planning and optimizing flow, as well as provide separation from known hazardous weather.

3. To fine tune aviation terminal forecasts (FTs), which currently cover all possible hazards and often overforecast local weather conditions, so that only germane hazards are forecasted; in addition, a more clear elucidation of terminal winds and hazardous areas is needed.

4. To improve winds aloft forecasts and identification of hazardous airspace, allowing for better pre-flight planning and in-flight rerouting strategies.

5. To provide the wake vortex advisory service with information about current and anticipated atmospheric conditions. Without precise knowledge of wake vortex location and movement, separation standards are arbitrarily large, thus decreasing capacity.

6. To provide pilots and controllers with easily understood weather products. Many current aviation weather products are highly coded, taxing the abilities of seasoned pilots, controllers, and meteorologists to interpret them. Significant meteorological warnings (SIGMETs) cover areas that are typically much larger than the extent of the actual hazard; nevertheless, they must be broadcast to pilots.

7. To provide en route users with critical information about local weather conditions. Numerical models have improved forecasts in the 8, 12, 24, 36, and 48 hour forecast periods, but they do not predict rapidly changing weather conditions in the short term of several hours. (Most continental U.S. flights are completed within 2 hours.) Warning and forecast offices and centers therefore have been established by the operational arms of the weather service to provide information about local weather events such as the location, movement, and severity of thunderstorms. However, this urgently needed information may not be transmitted to the aviation user, especially to general aviation pilots, in a timely manner, an important problem of connectivity between the National Weather Service's Weather Forecast Offices and the FAA's air traffic control facilities.

It should be noted that although the aviation system operates satisfactorily about 80 percent of the time, when weather is either "ceiling and visibility unlimited" (CAVU) or "Low Instrument Flight Rules" (LIFR), it is impacted negatively 100 percent of the time by poor information about marginal

Better weather information will foster less reactive and more strategic actions by air traffic controllers, managers, and pilots in adverse weather conditions. For example, information about the precise distribution of high-resolution winds aloft would enhance system capacity by supporting optimal routing and, in the case of the airport environment, planned runway reconfiguration during changing local wind conditions. Aviation-user-friendly weather products would assist controllers by allowing them to anticipate rerouting aircraft when inbound flight paths are blocked by hazardous convective activity, icing, and turbulence. Controllers would have precise information that predicts, within a few minutes, when an airport's capacity will be restricted by heavy snow, or when the passage of a gust front will necessitate a runway change. Information about the impact on terminal operations by hazardous weather, including snowfall rates, de-icing activities, snow removal operations, and wake vortex advisories, could be used by en route controllers, traffic managers, and Automated En Route Air Traffic Control, as well as by terminal controllers and managers using the Terminal Air Traffic Control Automation system. The aviation weather system would provide the requisite information to enable automation systems to balance controller workload and maintain capacity in adverse weather.

Delivering advanced, user-friendly aviation weather products and (where needed) high-resolution data to automation systems, pilots, controllers, and traffic management will ensure improvements to:

- Safety, by providing timely weather hazard products of much higher definition and usability.

- Capacity, by providing both routine and high-resolution weather hazard products to foster strategic planning during adverse weather situations.

- Efficiency of airspace utilization, by leading to a four-dimensional air traffic control system with a four-dimensional weather system.

- Communications between controllers and pilots, which will be reduced when the aviation weather system provides requisite and timely weather information to cope with adverse conditions.

A need or requirement for a four-dimensional weather system is based on the concept that a broad consortium of weather capabilities can produce a highly resolved weather system which includes a very high temporal structure. The air traffic control system should begin now to accommodate four-dimensionality in its advanced stages of modernization.

Atmospheric Administration, and the Department of Defense. Doppler radars for en route and terminal areas, weather satellites, automatic surface weather observing systems, wind profilers, in situ atmospheric measurements taken by aircraft, and lightning detection systems form a groundwork for greatly improved weather resolution. In the U.S. heartland, where observations are planned to be most dense, the number of daily weather observations may increase by as much as 30 times by the year 1995 and perhaps by 50 times early in the next decade. The state of the atmosphere will be known in detail, including temperature; humidity; wind; all types of precipitation such as rain, snow, and freezing precipitation; cloud type and extent; and pressure. Aviation-state weather variables will be known similarly, including the extent of thunderstorm conditions, windshear, icing and ground icing conditions, ceiling and visibility changes, and turbulence.

In addition to enhanced observational systems, ongoing improvements in parallel-processing computers and communications technologies will allow for similarly enhanced capabilities in weather processing and dissemination. The federal agencies that focus on weather have created, or are in the process of creating, real-time weather processors that will assimilate thousands of times more weather data, and will provide those data to weather information displays that allow for a much more clear description of weather conditions. Major advances in weather forecasting models will make routine short-term prognostication of aviation weather conditions on 1, 2, and 3 hour scales. Other weather information extrapolation techniques will allow for very short term forecasting capabilities in the 1, 5, 10, 30, and 60 minute time frames, important for turbulence and windshear warnings.

An example of where this very short term capability applies is in wake vortex forecasting, detecting, and warning, included in this vision of the future aviation weather system because of the close association wake vortex detection and decay has with aviation weather sensors and certain atmospheric conditions. Needed are microwave Doppler and light detection and ranging (lidar) radar systems that can positively identify vortices, and very high resolution wind field mapping over the airport, necessary for tracking detected vortices, to create major advances in a workable wake vortex advisory service. By having an expanded capability to measure and reliably forecast the atmospheric conditions that cause wake vortices to advect and/or decay, one can provide weather-adaptive wake vortex separations. The Terminal Automation System should permit the practical and safe utilization of such separations without increasing controller workload.

Other improvements include:

- Airborne hazardous weather detection systems will provide warnings to flight crews. These warnings could then be sent automatically to other flight crews en route. In an advanced weather system, this airborne sensing capability (now in its early stage) will grow immensely to include infrared and lidar clear air turbulence sensing, Doppler radar sensing of windshear, lightning detection, and a host of aviation-state variables, including humidity, the presence of icing, and the presence of the aircraft in cloud conditions.

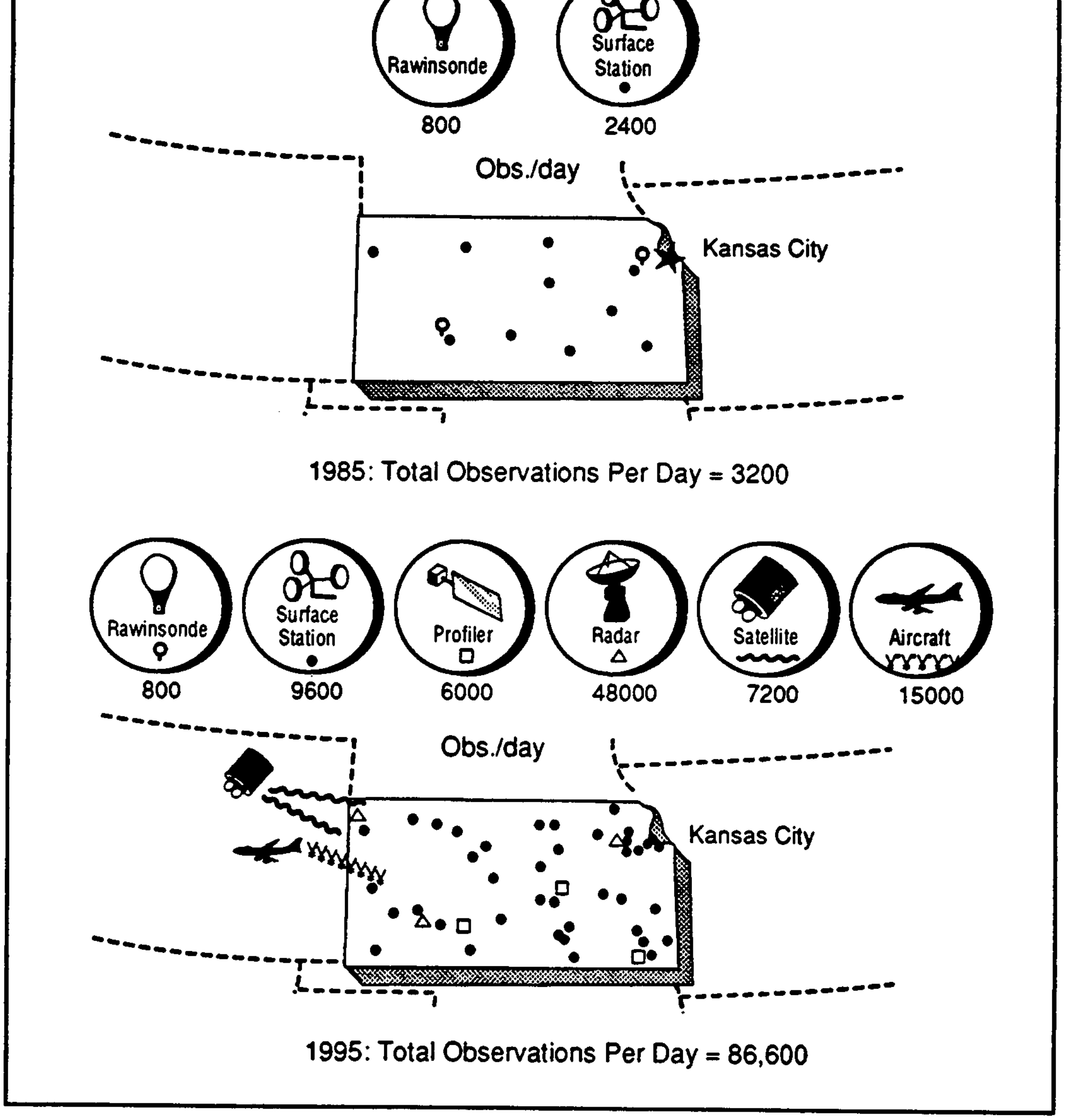


Figure 1. Instead of today's 250 mile and 12 hour resolutions, observations in the early 21st century will be characterized by 1–5 mile and 5 minute resolutions.
(Source: Alexander MacDonald, NOAA/ERL/FSL)

communications, integrated with the navigation system for precise location, will provide this new information to flight decks worldwide.

To some degree, the deficiencies of the current aviation weather system have been addressed for the past decade. An extraordinary array of new weather sensors and processors, along with an improving understanding of the aviation weather science, has been evolving. Some of these new systems (e.g., Terminal Doppler Weather Radar and Low-Level Windshear Alert System) have paved the way to a future vision for a even better aviation weather system.

A New Aviation Weather System for the United States

The FAA will establish aviation weather product generators to provide useful weather information to all classes of pilots, controllers, traffic managers, and other users. This is in stark contrast to the weather data overload that is rapidly accumulating in today's weather system.

Terminal Area Airspace

The Integrated Terminal Weather System will receive gridded observation and forecast data from the National Weather Service every 5 minutes and combine them with FAA terminal sensor data (e.g., from the Terminal Doppler Weather Radar and Enhanced Low-Level Windshear Alert System). It will generate four-dimensional estimates of the current and predicted hazardous weather and distribute the information as products to pilots via data link and to flight controllers via graphical displays. Traffic managers will be able to rely on Integrated Terminal Weather System information to ensure efficient airspace operations. Air traffic management computers will use Integrated Terminal Weather System information to maximize traffic acceptance and departure rates at high-traffic airports. Programs associated with the Terminal Air Traffic Control Automation such as the Center/Terminal Automation System will be able to use high-resolution information about winds to provide four-dimensional metering, spacing, and rerouting of inbound and outbound traffic. These products will be user-friendly and not require interpretation by a meteorologist.

Pilots will have advanced onboard graphics screens that integrate weather hazard information with a four-dimensional navigation system and traffic control instructions. Highly succinct textual products also will be available. For example, the Integrated Terminal Weather System will provide simple, textual microburst alerts:

MICROBURST ALERT, EXPECT 60 KNOT LOSS ON 1 MILE FINAL

coupled with situational color displays of severe windshear hazard areas. The Terminal Doppler Weather Radar and enhanced Low-Level Windshear Alert System have this windshear warning and "no go" space, airspace capacity could be increased by as much as 25 percent in many types of weather conditions and maintained when it would otherwise be lost in today's system. However, certain weather events such as blizzards will still close airports.

En Route/Regional Airspace

For the en route airspace, a Regional Aviation Weather Products Generator will be situated in the Area Control Facility. Typical resolutions of this domain will be in the 1 minute and 1 mile range, somewhat more coarse than the Integrated Terminal Weather System domain, but many times more detailed than today's system. High-resolution hazard and operationally significant weather products will be delivered to pilots via data link and to controllers and traffic managers via the Advanced Automation System. The Advanced Automation System (e.g., using Automated En Route Air Traffic Control) will ingest highly resolved weather data for planning to maximize airspace usage in the Area Control Facility airspace by employing the products of the Regional Aviation Weather Products Generator.

National Airspace

The national airspace environment will also be protected by an advanced, high-resolution system. At the Central Flow Control Facility, a National Aviation Weather Products Generator will provide traffic managers and traffic management computers with a mosaic of weather hazards for the continental United States, similar to that provided by the Integrated Terminal Weather System and the Regional Aviation Weather Products Generator. The resolutions will likely be a coarser 10 minutes and 25 miles, sufficient for national traffic management purposes. Ceiling, visibility, and other acceptance restrictions will be closely monitored at hub airports on time scales of a few minutes to 6 hours, the duration of a transcontinental flight. Consequently, a one to three hour terminal forecast will be valuable to traffic management and of great interest to central flow control. With an improved wind mapping capability in the one to three hour forecast, national air traffic management of traffic flow will become significantly more efficient, a capability that will be enhanced when thunderstorm cells, snowstorms, and reduced ceiling and visibility conditions are much more succinctly known.

The Automated Flight Service Station will have advanced graphic and textual capabilities emanating from the Integrated Terminal Weather System, Regional Aviation Weather Products Generator, and National Aviation Weather Products Generator. A new-generation Flight Service Automation System will use products from the Regional Aviation Weather Products Generator to provide route-specific weather conditions for general aviation pilots querying the Automated Flight Service Station.

All components of the future system will have route-specific information available by computer; only the aircraft location and intended route are needed to provide route-specific weather

The role of weather vendor services will be greatly enhanced through satellite broadcast of Integrated Terminal Weather System, Regional Aviation Weather Products Generator, and National Aviation Weather Products Generator data bases. Sharing the improved strategic assets of the FAA's traffic management system, airline dispatchers will be able to adapt their operations to better deal with restricted weather situations.

Oceanic Airspace

The U.S. aviation weather system is important to international transoceanic flights. With continuing pressure on the capacity of the transatlantic and transpacific routes, and with the advent of satellite navigation and communications, the need to provide short-term information regarding rapid changes in adverse weather conditions en route will become critical. A transoceanic weather warning and forecast system will provide these advisories, using weather satellite monitoring and improved hemispheric forecast models. Onboard weather measurements from aircraft flying these routes will be linked via satellite to weather processors in oceanic weather warning and forecast centers that serve these routes. Oceanic weather improvements will be important to both strategic planning (e.g., better optimal routing with more closely spaced routes) and tactical planning (e.g., the ability to make rapid route shifts due to turbulence, convective cells, and small-scale jet-stream features. This is in contrast to today's rigid routing and separation standards that allow little flexibility in diverse weather situations.

Evolving to a Viable Operations Concept for Aviation Weather

Improving weather data, developing a data-delivery system, and providing aviation users with products is the government's framework for evolving to an advanced aviation weather system. Hardware and software infrastructure and interfaces can be sketched out early in the design process so that as components of the envisioned system are defined, they can be demonstrated and implemented quickly. The envisioned future aviation weather system takes full advantage of existing FAA and National Weather Service assets. The integrated Terminal Doppler Weather Radar/Low-Level Windshear Alert System is a prime example of expected high-precision improvements, involving explicit textual and graphical user-friendly products.

Evolutionary strategy will focus on quickly developing prototypes with key related systems such as the FAA's Center/Terminal Automation System and the National Oceanic and Atmospheric Administration's Gridded Forecast System and Advanced Weather Interactive Processing System to ensure that interfaces and operations concepts are thoroughly validated. Prototypes will be demonstrated in an operational environment (test beds), and feedback from user evaluation teams will help refine them.

hazards become more accurate, routing changes will occur less tactically and be more strategic. Optimal route selection, which factors in weather and traffic information, will be determined through a cooperative decision-making process between the pilot and controller.

Human factors considerations of information system design and sensory overload must be taken seriously. In the cockpit, obtaining or assimilating weather information cannot detract from controlling the aircraft. Complex keystrokes or the necessity of orienting a graphic product to the direction of flight will be avoided. At the controller's console, weather information will require little or no interpretation and not detract from ensuring aircraft separation; it will be integrated with the controller's primary display, as airways and fixes are depicted today.

The appropriate components of the aviation weather information system will, through direct connections and via data link, provide more timely, more accurate, and higher resolution data to the future air traffic control automation, flow management, and cockpit systems. A four-dimensional navigation system onboard the aircraft could request and use information regarding winds aloft, requiring no more human effort than monitoring. A terminal automation system could estimate aircraft arrival over the arrival gate by taking into account a severe thunderstorm ("no-go" space) that will force rerouting. A similar en route automation system could provide automatic rerouting around hazardous weather areas, with much greater strategic planning than is possible today.

In light of these significant operational and technological advancements, a major effort to re-educate all users of the airspace system will be necessary. Pilots and controllers nearing retirement today have spent their entire careers learning to cope with many of the same weather products that were available when they began working in the 1950s. Our most competent flight professionals take the current, imprecise forecasts with a grain of salt, while worrying about liability when forecasts show a chance of hazardous weather in nearly every prediction.

There are immediate, critical tasks before us. A description of the current state of the atmosphere is an unmet need today. We need to describe the state of the atmosphere with greater clarity, even without the new sensors, processing, automation, and communications envisaged early in the next century. The evolution of the aviation weather system to a truly four-dimensional weather system can be accelerated by developing a capability to digitize what today is essentially an analog system. By so doing, we can maximize current capabilities, making the baselined National Airspace System more effective, meeting more immediate weather needs of the users, and positioning the current aviation weather system to phase into the future weather vision with greater success.

capabilities much more effectively than today's limited weather information products. With an open-ended design and development strategy, improvements will be integrated into the system in a smooth, continuous process.

Users will be able to fly preferred trajectories. The situational weather awareness of pilots and controllers will be enhanced. Users will know where hazards will be located, minutes to hours in advance, allowing for strategic planning, with air traffic control's assistance, to avoid these areas. Traffic routes will be adjusted perhaps hundreds of miles before encountering hazardous weather, providing for a smooth circumnavigation. Voice congestion on air traffic control frequencies will decrease. Some reduction in large fuel reserves will be realized with more accurate weather forecasts. Airspace over the oceans will have a much-increased capacity as improved tactical and strategic planning become possible with improved oceanic weather information. Most importantly, weather factors that currently limit aircraft operations will be predicted with much greater accuracy, resulting in greater safety, efficiency, and capacity of the National Airspace System.

demand, improvements in air traffic communication systems will be necessary. FAA's goal is to continue to operate an efficient, seamless and robust communication system with performance adequate to meet the needs of a broad user spectrum, while allowing smooth evolution, growth and global interoperability. FAA will take advantage of new technologies, leverage commercially available services, lead the development of industry-preferred standards and promote partnerships with industry in order to minimize system implementation risk and speed introduction of air traffic and airline operational services to the aviation community. The future vision for the Air Traffic Management (ATM) communication system includes a reduced need for user involvement in the communication process, diverse systems, and expanded coverage through the application of satellite technology.

The purpose of this paper is to provide a broad view of plans for development of the ATM communication system to support orderly evolution of the National Airspace System. A brief overview of the current communication infrastructure is provided. Major drivers for change within the ATM system are described along with their impact on communication operations and architecture.

Objectives for the Air Traffic Management communication system are determined by ATM functional needs, as shown in Figure 1.

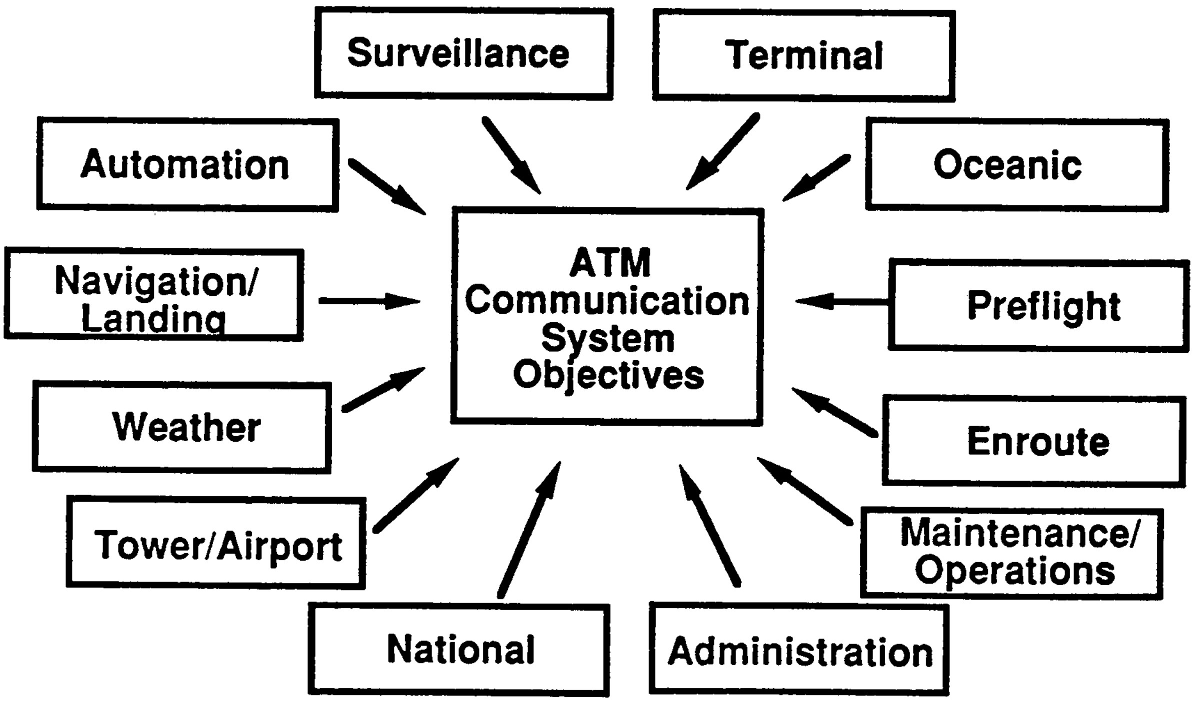


Figure 1. Functions Supported by the ATM Communication System

• expanded delivery of real-time weather reports to users;

• sharing extensive weather databases across the aviation community;

• improved communication capacity and performance to support increased oceanic route capacity;

• increased communications capacity and reduced response time to

BACKGROUND

The National Airspace System Plan, for which implementation began in 1981, set in motion a series of developments, the majority of which are nearing completion. Figure 2 illustrates the key currently implemented and planned communication systems that were initiated under the NAS Plan. Descriptions of the systems and their implementation programs are contained in the FAA's Capital Investment Plan (CIP)[2].

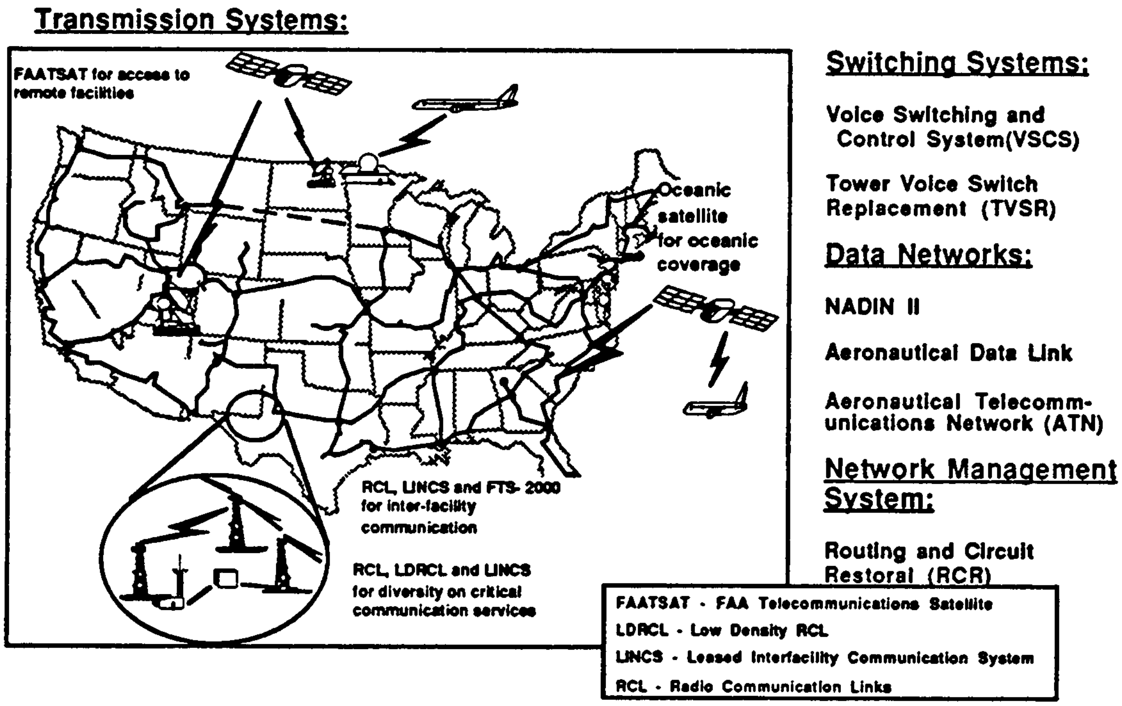


Figure 2. Key ATM Communication Systems

three areas in which there are needs for enhancement of the current plan: network management, digital transmission and air/ground communication. Planning system enhancements to meet user needs in these areas begins with identification of improvements that will provide direct and substantial benefits to the users. For example, in air/ground communication, contains the means for eliminating this element of pilot and controller work load. It would also eliminate the distractions generated by frequency changes. Hence, one of the improvements that is under consideration is automatic communication channel management. This potential improvement and others are discussed in the following sections.

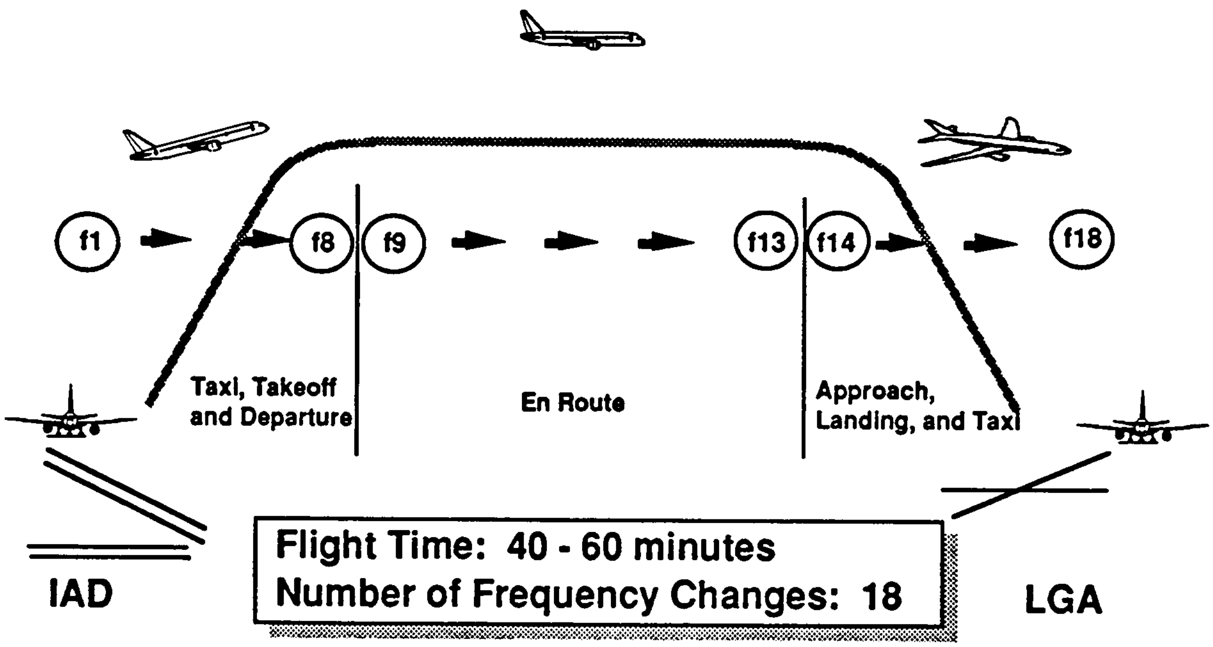


Figure 3. Washington, Dulles-to-New York, LaGuardia Flight Scenario

FUTURE VISION: EVOLVING WITH TECHNOLOGY

Air traffic communications will evolve away from voice communication to use data as the principal mode of communication. The needs of the key operational domains and functional areas will be met by an integrated communications infrastructure that will support multiple complementary air/ground and ground/ground transmission systems to provide highly reliable communication in all phases of operations. The system will dynamically adapt to changes in connectivity, and it will provide efficient, reliable computer-to-computer data transfer to support the integration of cockpit and ground system automation. Forthcoming developments to realize this vision are discussed in the following paragraphs.

example, piloting aircraft without diverting attention to details of communication resource management. Tasks that can be eliminated include tuning to the next air traffic control (ATC) frequency. In addition to reducing work load, automatic frequency management also reduces errors due to mistakes in manual tuning.

Call processing controls will eliminate the contention, such as simultaneous keying of transmitters, that occurs today in busy, manually operated systems, in which a controller may be responsible for as many as fifty aircraft. It is estimated that communication system improvements could reduce a controller's work load by about ten percent. Complementary improvements will be made in cockpit communication systems to aid pilots by reducing distractions from urgent tasks. Attention to cockpit human factors, including integration of equipment design and operational procedures will ensure safe and efficient operation. The technology for these improvements is readily available in commercial communication systems.

A technological key to many of the benefits of modern air traffic communication systems will be software-controlled networking. Placing the network of the future under software control will facilitate the improvements discussed above and make it possible for the network to adapt quickly to meet changing demands--establishing new routes and hubs, for example.

Advanced network management systems will facilitate end-to-end management of communication services. Diverse voice and data transmission facilities will be integrated to enable speedy recovery from catastrophic failures such as the recent public telecommunications network failures.

composition of the network is expected to shift to approximately 50 percent voice, 50 percent data. Voice will continue to be a universal means for air/ground and air/air communication, for emergencies and other tactical communications for all aircraft, as well as the primary means for communication with non-data-equipped aircraft. The transition to data communication has begun and will continue gradually until the majority of strategic air/ground communications are accomplished by exchange of digital messages. The voice channel will be available for use as needed. Strategic messages are those that are sent in advance of anticipated action, whereas tactical messages are generally delivered close in time to the anticipated action. Strategic communications such as weather data, Notices to Airmen (NOTAMs), flight plans and clearances, which are typically transmitted by voice today, will evolve to data. As data communication and automation capabilities expand, new data exchanges will be added to the roster of routine communications.

A key consideration in the transition from voice to data communication is how to adapt the new system to accommodate or replace the situational awareness that pilots currently have from the "party line" method of operation that is inherent in the current air/ground communication system, i.e., the ability for all pilots to hear all activity in their immediate area. The challenge is to reduce work loads while increasing the accuracy and reliability of the controller/pilot connection.

Increasing Interoperability

The principal means to achieving increased interoperability will be to broaden the use of industry and international standard interfaces and protocols for voice and data communication. Standard interfaces and protocols will allow diverse transmission

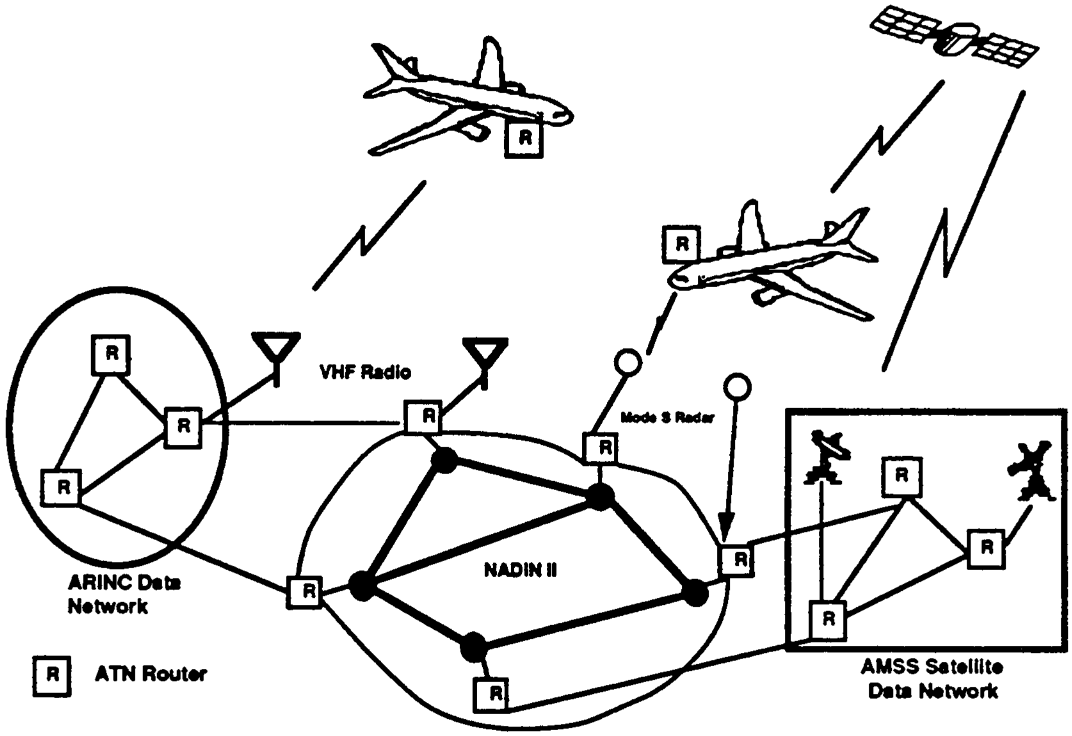


Figure 4. The Aeronautical Telecommunications Network

Standard equipment and procedures will improve access to communication services throughout the aeronautical community. They will also promote interchangeability of systems, so that future expansion and addition of new features can be accomplished quickly, at low cost, without special development.

Increasing Communication Capacity

Air Route Traffic Control Center (ARTCC) Instrument Flight Rules (IFR) operations are growing at approximately two percent per year. The air traffic communication system of the future must grow at a pace that accommodates such growth in demand for air traffic services. There are two potential bottlenecks that deserve special attention in planning for system capacity enhancement in the next generation air traffic communication system.

One is the need to accommodate increased international travel on the Atlantic and Pacific trans-oceanic routes. Trans-oceanic communication will be significantly improved by the application of satellite technology, as discussed in the following section.

The second is the need to expand the capacity of the air/ground very high frequency (VHF) radio system. The present

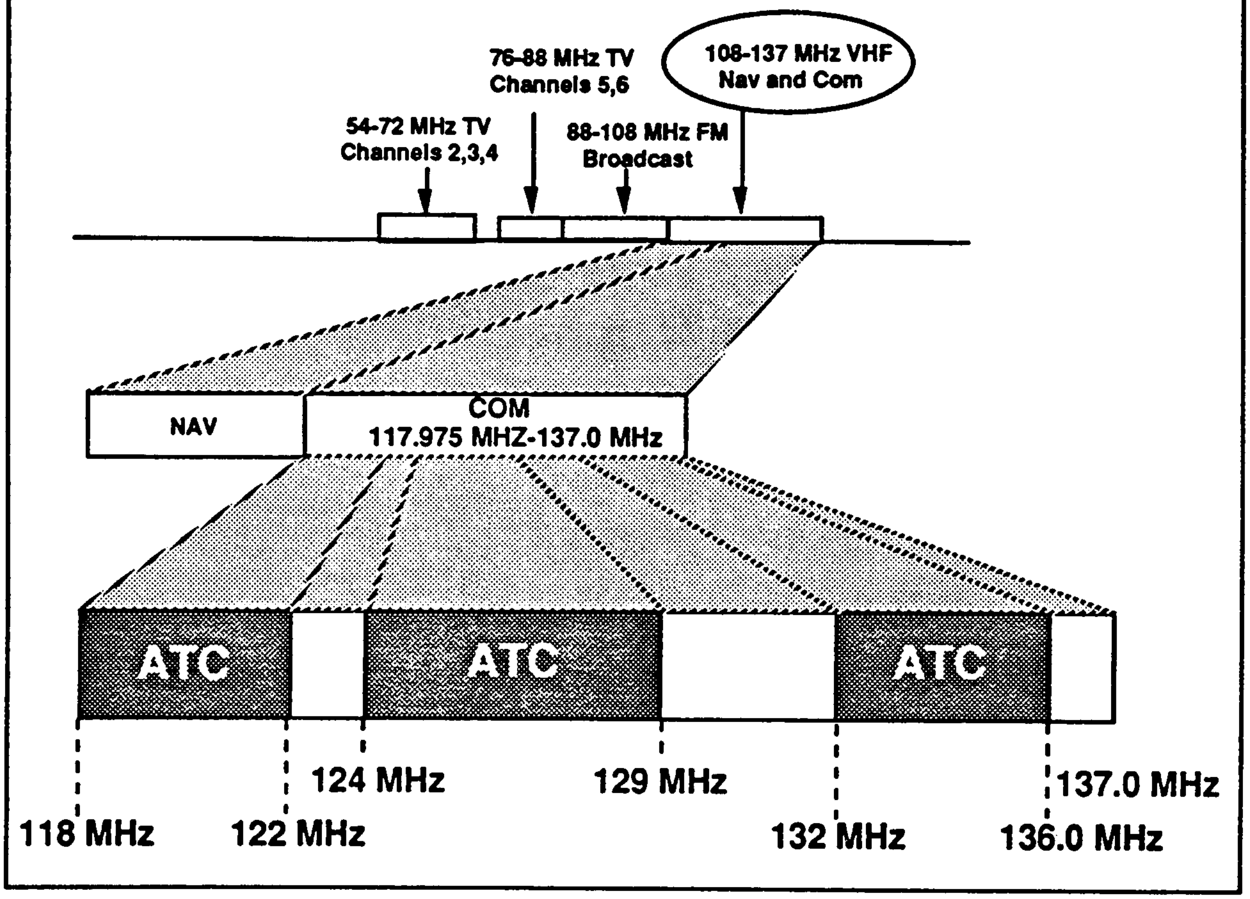
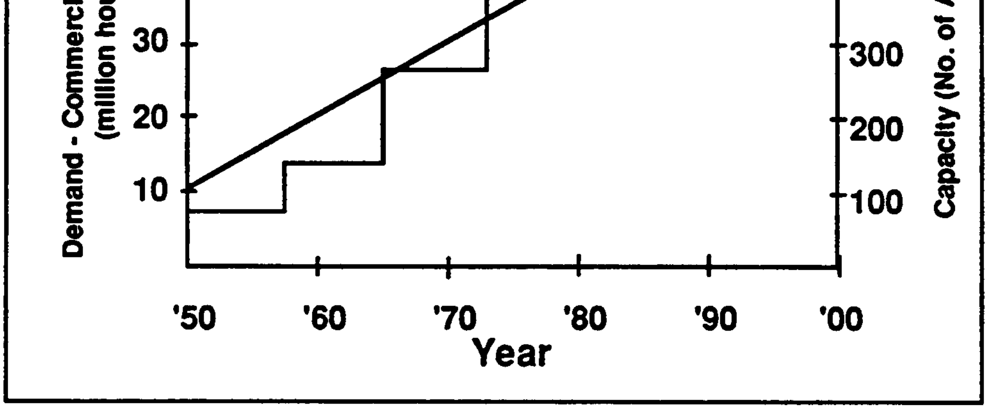


Figure 5. VHF Air/Ground Spectrum

Options for achieving the necessary expansion are currently under consideration in the International Civil Aviation Organization (ICAO) and the Radio Technical Commission for Aeronautics (RTCA). A key option is conversion to a digital system, which would provide the needed capacity improvement and broad-based capability for advanced features such as those discussed in previous sections. It is anticipated that the governing bodies will support conversion to a digital system, thereby laying the foundation for advanced features that can be implemented in future generations of the air/ground communication system.

Expanded Coverage

Satellite communication systems and complementary avionics packages have reached the stage of maturity and cost-effective performance to serve significant roles in air traffic communication. For the future, satellite systems will greatly improve trans-oceanic air traffic communication, and they will continue to provide important options for access to remote areas as well as wide-area broadcast and data collection.



Congested ATC spectrum

- Approximately 525 25 kHz channels available in ATC spectrum. 501 (95%) in use as of July 1991.
- Accommodation of older (50 kHz) radios and other allocations reduce the number of available channels.
- U.S. will exhaust spectrum in 5 to 10 years.

Figure 6. VHF Air/Ground Demand and Capacity

REALIZATION OF THE VISION: OPERATIONAL APPLICATIONS OF NEW TECHNOLOGY

Although there are a number of new developments already underway, there are many choices yet to be made in the development of the next generation air traffic communication system. Following are sketches, based on the capabilities of current technology and estimates of how, in an orderly transition, technological improvements could be introduced operationally into the global air traffic management system. Figure 7 summarizes the current view of the future ATM communication system.

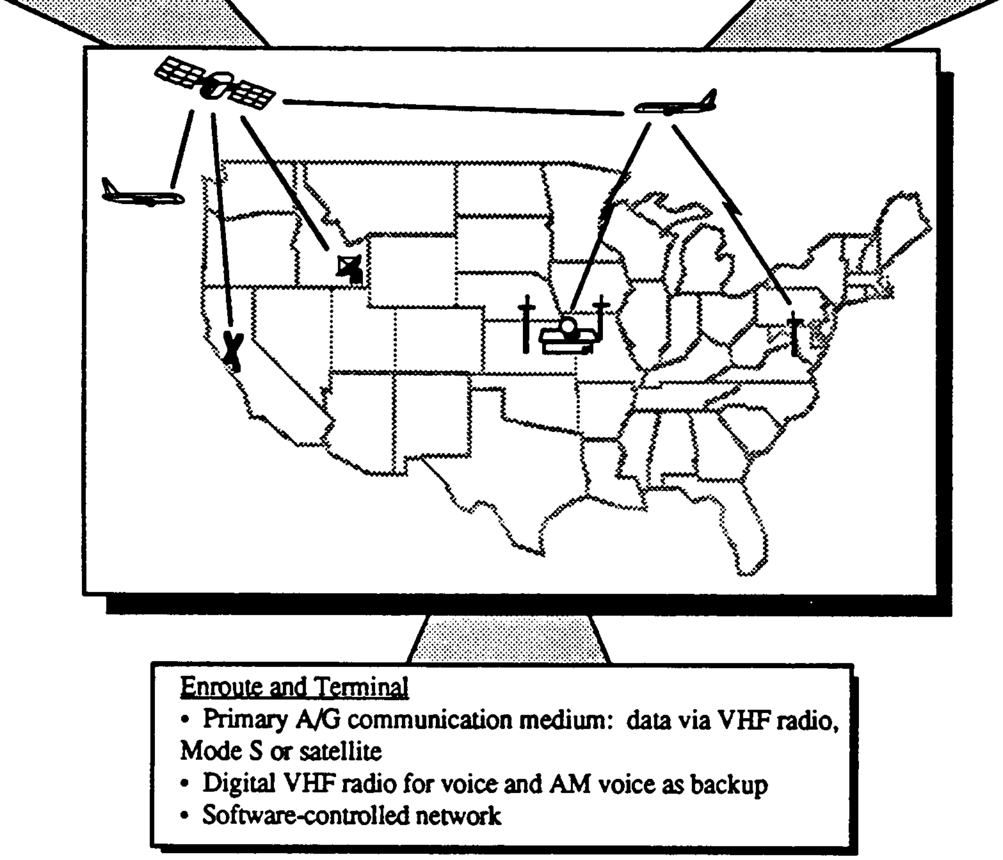


Figure 7 - Future ATM Communication System

Oceanic Domain

Satellite communication will provide the primary medium for voice and data communication in the oceanic domain. The majority of air traffic control (ATC) communications will be via satellite data communication. Position reporting will be automatic and based on GPS position determination. High frequency (HF) radio will provide backup voice and data communication capability and will assume a primary role in polar regions. The Traffic Alert and Collision Avoidance System (TCAS) will provide secondary separation assurance.

In choosing among specific alternatives for improving oceanic domain communication, the key issue is overall communication system reliability/availability, because closer route spacing requires greater assurance that communication services will be available at critical times. Trade-offs are being examined among potential satellite and HF system improvements that will increase overall system availability consistent with increased route capacity goals.

Airport Surface Domain

High-volume airline operational communication will be carried via direct high-speed connection to the aircraft at the gate.

Enroute, Terminal and Flight Services Domains

Air/Ground Communication. Air traffic control air/ground communication will evolve from primarily voice communication to primarily data communication. Aeronautical VHF radio systems will transition to digital modulation to improve voice quality and increase channel capacity. Digital VHF capability will provide a third air/ground data channel (along with Mode S and satellite), for the Aeronautical Telecommunication Network, increasing data communication capacity and reliability. Voice communication will continue to be used for emergencies and for those aircraft that are not data equipped, and amplitude modulated voice will continue to be supported as well.

Ground/Ground Communication. The air traffic management network will evolve to a predominantly digital, software-controlled network. The data communication infrastructure will include dynamic routing of packet data messages based on the type of service, cost of transmission and other parameters, and improved security in network access and control. Independent and geographically diverse transmission, including demand-access satellite service, expanded transmission system diversity, intelligent switching nodes and data routers, and centralized operation, administration and maintenance will be implemented to ensure connectivity. National traffic flow management operations will collect comprehensive aircraft position and status data over the ground and space-based networks.

efficiency.

The future network will be software-controlled, to support advanced capabilities and promote efficient use of resources. Operational and administrative communication planning will be integrated to further promote cost-effective use of resources. Planning will focus on leveraging industry-standard products and services to reduce development costs and speed introduction of new technology. The FAA will take a leading role in setting future industry standards, to ensure that unique safety-related requirements can be met with standard products and services. Where appropriate, major functions, such as voice and data transmission will be leased as services in place of costly system development.

The future vision of air traffic communication described above will, when realized, greatly enhance the safety, capacity, and efficiency of the air traffic management system. Building on current technology, air traffic communication systems are evolving to meet the demands posed by projected increases in air traffic, and to respond more effectively to user needs and preferences.

GPS	Global Positioning System
HF	High Frequency
ICAO	International Civil Aviation Organization
NAS	National Airspace System
NOTAM	Notice to Airmen
RTCA	Radio Technical Commission for Aeronautics
VHF	Very High Frequency

Definitions

Air Traffic Control: The safety separation process to prevent collisions between aircraft and collisions with obstructions while expediting and maintaining an orderly flow of air traffic; an element of the air traffic management process.

Air Traffic Management: The process used to ensure the safe, efficient, and expeditious movement of aircraft during all phases of operations. Air traffic management consists of air traffic control and traffic flow management.

Notice to Airmen: A notice containing information concerning the establishment, condition, or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

Mode S: A secondary surveillance radar and communication system in which each aircraft is assigned a unique address code. Using this unique code, interrogations and other messages can be directed to a particular aircraft, and replies can be unambiguously identified.

Tactical Communications: ATM communications that are developed and delivered as part of the real-time ATM process.

Traffic Flow Management: The process that ensures optimum flow of air traffic to and through areas during times when demand exceeds, or is expected to exceed, the available capacity of the system; an element of the air traffic management process.

User-Preferred Trajectory: The route, altitude profile, speed, and times of departure and arrival that the user prefers.

References

1 Federal Aviation Administration, "Concepts and Description of the Future Air Traffic Management System for the United States," April 1991.

2 Federal Aviation Administration, "Aviation System Capital Investment Plan," December, 1991.

Introduction

This surface movement vision of the future provides a road map to guide changes in procedures, technology, and training to improve operations. The vision of the future, combined with aviation community consensus on the transition to the future, provides guidance and direction for research and development and for subsequent investment decision making.

This vision is the first step in the process of defining the airport surface operations and systems of the future. It provides an overview of the products and services that are believed necessary to meet the vision goals. It does not present a detailed definition of a future system or system components and does not discuss developmental risks. Some capabilities and technologies are more clearly defined and will appear early; others are more speculative and will require further research. The Federal Aviation Administration's (FAA) intent is to continue to refine the vision of the future airport surface movement through technical and operational forums, while reaching for and maintaining aviation community consensus.

The airport surface movement vision goes beyond the technical issues of communications, navigation, and surveillance in the 21st century. The FAA and the users (pilots, air carriers, airport operators) must examine surface movement as a *system* that links the airspace to the surface and moves aircraft safely and efficiently on the airport. To achieve maximum efficiency, the surface movement system must take the aircraft from the gate and sequence departures into the terminal airspace. This same system must efficiently manage arrivals and guide the aircraft to the gate. The surface movement system of the future is made up of integrated air traffic management services, airport facilities and services, and user services all linked by automation designed to move the passenger, the ultimate customer of this system. The common thread linking components of the system is shared information between air traffic controllers, the airport operator, and the airport's users.

The objective is gate-to-gate movement of aircraft through the National Airspace System with minimal constraint and maximum efficiency in terms of time and energy consumption.

A linkage between ground operations and flight operations will be accomplished through automation, taking advantage of time-based air traffic management. Aircraft avionics necessary for communications, navigation and surveillance in the air will be designed to provide value-added benefits to aircraft operators while moving on the ground. Likewise, surveillance supporting air traffic control should be extended to operate on the airport surface. Basic features common in the airborne air traffic control system--features like positive target identification and conflict alert--should exist on the airport surface. Air traffic management and automation necessary to improve efficiency in the airspace, such as terminal air traffic control automation, will be linked to movement of aircraft on the ground.

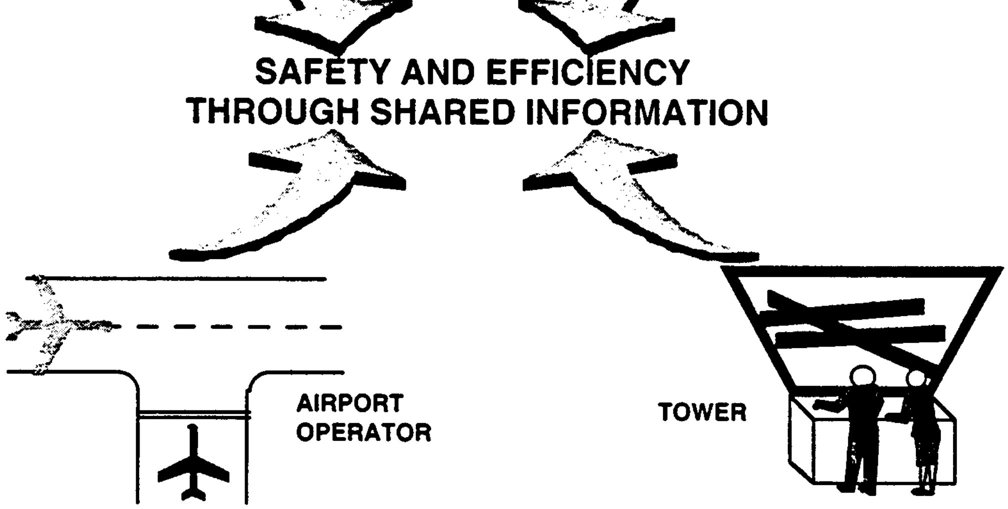


Figure 1. Surface System Goal of Shared Information

Surface Movement Vision Goals
Surface movement goals have been established that provide both a framework for discussion and a performance improvement target for the future:

- o The pilot and controller should have the same expectations of performance on the airport, based on a mutual sharing of information to improve safety, efficiency, and capacity on airports.

- o Pilots, controllers, and ground vehicle operators must have clearly defined roles and responsibilities that eliminate procedural ambiguities that lead to operational errors and pilot/vehicle operator deviations.

- o While benefits will flow to all airports, development and improvements to surface movement safety, guidance, and control should focus on the nation's large airports.

- o Improve surface movement safety through an 80 percent reduction in runway incursions by the year 2000 from the 1990 high of 281 reported events.

- o Ground taxi-in and taxi-out average delays should be reduced by a minimum of 15 percent from the 1990 level, and further improvements should allow for growth in operations without increases in ground delay.

- o Surface movement communications, navigation, and surveillance must be able to accommodate all classes of aircraft and necessary ground vehicles.

visibility.

- o Surface movement automation supporting air traffic management should provide linkage with terminal and en route airspace automation, producing a seamless, time-based operation that delivers the aircraft to the runway for an on-time takeoff, recovers it on landing, and moves it to and from the gate with reduced controller and pilot workload.

- o Airport visual aids (signs, marking, and lighting) providing guidance while taxiing should become an integrated component of the surface movement system.

Surface Movement Safety

Safety improvements must consider (1) operating with increased traffic loads and (2) greater demand to operate in extremely low visibilities (below an RVR of 600 feet to as low as 300 feet). While the airport will achieve capacity and efficiency gains by allowing operations in low visibilities, surface safety will be the controlling factor. Safety considerations include preventing runway incursions and surface collisions between aircraft and ground vehicles operating on the runways and taxiways. Surveillance and ground navigation improvements will be needed to support growth in low-visibility operations. These improvements include system components in the control tower, in the cockpit, and on the airport surface.

The safety challenge in preventing runway incursions and surface collisions requires dealing directly with human error, those

at any point in the chain can break the error pattern and prevent the incident.

Surface movement safety, guidance, and control will continue to be a human-centered activity well into the 21st century. Automation needs to assist the controller and pilot in monitoring the dynamics of surface operations, identify apparent errors, and reduce work load. Therefore, safety technology should be used to prevent potential or actual errors and alert controllers and/or the pilot so they may intervene.

Surface safety must be continually refined as demand increases. This means that any technology must be deployed in a modular fashion, be expandable, and have the necessary open system interconnects to allow the system to evolve with demand.

Surface Automation

Surface automation is a mix of automated components linked together with appropriate interfaces to support information flow between automation functions. Included in this vision are functions illustrated in Figure 2. Most of these interconnects are computer-to-computer. The goal of automation is to produce a seamless air traffic management and surface movement system. Terminal air traffic control automation (TATCA) must be able to communicate with airport surface traffic automation (ASTA). Information must flow between these two programs and the Tower Control Computer Complex (TCCC) which provides automation support to the controller. Traffic planning functions must support time-based air traffic management. Integration of surface and tower functions will exist so that information from surveillance can be used to control automated building more runways and taxiways. Efficiency must come from using the existing physical assets better--through improved sequencing of departures and more tactical management of aircraft movement. Air traffic management in the airspace must be integrated with traffic management on the ground. Expeditious travel on the ground depends on improving departure throughput. Congestion over the departure fixes, airborne separation, and wake vortex interval spacing requirements dictate efficiency and throughput in the departure queue. With improved sequencing of the aircraft in the departure queue, departure fix loading can become balanced and improvements in ground travel time can be achieved.

These improvements in ground travel time require a higher degree of cooperation and information sharing between the FAA air traffic controller, the airline ramp controller, the pilot, and airport operator on the changing surface and airspace situation. The ramp controller will use surface movement information tactically to manage aircraft start and push back times, gaining optimum sequencing for departure. The FAA ground controller takes the next step to integrate the departures as they leave different gate areas.

In bad weather, aircraft sequencing must consider deicing requirements, crew qualifications for low visibility operations, and the orchestration of snow removal operations. Any improvement in the ability to continue operations when weather is poor leads to significant system-wide benefits through reducing delay.

For arrivals, efficiencies can be gained by the airlines knowing when an aircraft is on final approach and has landed. Both the pilot and situational data (display of surface traffic information) to support airport rescue and fire fighting response, improve snow removal operations, increase control of ground vehicle operations, support runway/taxiway maintenance activities, and improve facility management.

Airlines could manage their support services (baggage, catering, fueling, etc.) more efficiently through sharing situational data. They could use improved information to stage their support teams to improve aircraft handling and turnaround time.

Communications

Figure 2 illustrates the automation and communications interconnects for systems involved in surface movement and traffic planning. Air traffic control communications on the airport surface will migrate to a mix of voice and data link capabilities with automated communications between system components that move situation information between the users. Communications from surface automation directly to the cockpit via data link will be common.

Voice communications will continue to be used for taxi instructions for maneuvering traffic on the airport surface. Voice communications allow pilots to be part of a "party line" which is necessary for maintaining situational awareness and avoiding blunders onto the runway. Experience at joint-use civil/military airports shows that pilots experience more difficulties in maintaining situational awareness because some military aircraft are on UHF frequencies while the civil pilots are on VHF. This condition would worsen if some aircraft

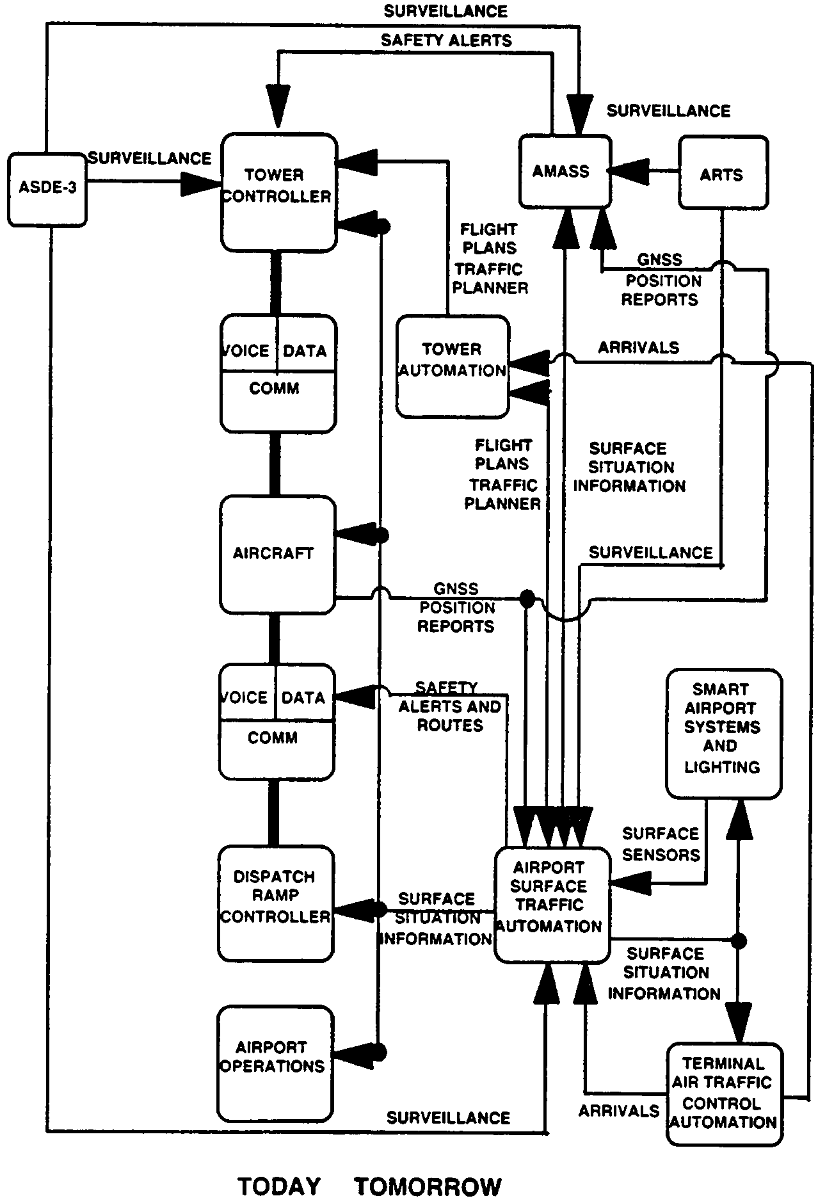


Figure 2. Surface System Interconnects

data link, frequency congestion will be reduced. Clearances for landing and takeoff could also go via data link without affecting the "party line", provided other aircraft also received the information when it affects their own operation. The ability to go from a data link message to a synthesized voice message sent over voice communication channels is also possible, reducing controller work load.

Both voice and data link taxi instructions can be abbreviated by using standard taxi route charts in the cockpit. The pilot receives a clearance much like a standard instrument departure clearance, where the route and its associated holding points are identified by a name instead of a detailed route description. These same surface charts will also be available in electronic form to be incorporated in the aircraft's flight management computer library. Prototype standard taxi routes have been introduced at Chicago O'Hare International Airport which are designed to be upwardly compatible with electronic mapping.

Arriving aircraft are tracked by the airline through the shared situational data. The ramp controller or airline can send gate information to the control tower through a shared network. This information appears on the tower's surface movement display and the pilot gets the latest gate information via data link or as part of the taxi-in instructions. This reduces the need for the cockpit crew to go off the voice frequency to talk to the company and find out the gate information, then return to the tower frequency and advise the air traffic controller. The air traffic controller

During low-visibility operations, communications work load would be reduced because the display of situational data contains the aircraft identification, eliminating the need for controllers to have pilots confirm their position or hold at position reporting locations during taxi operations.

Aircraft and ground vehicles not equipped with appropriate electronic equipment will continue to use voice communications.

Surface Navigation

Surface movement by visual reference using signs, lighting, and marking will continue to be the primary means of navigation. While numerous technologies may become available to enhance vision, the pilot taxiing the aircraft will still require outside references for guidance. This need for visual guidance means that zero visibility surface operations are not possible without enhanced vision capabilities. Vision enhancement technology needs to be capable of penetrating zero visibility conditions with sufficient clarity to allow the safe movement of the aircraft. A likely exception will be the high-speed civil transport, whose current design options include no out-the-window viewing. In this case, avionics for synthetic vision and video monitors will be needed to taxi.

For operating in low visibility, at night, or at an airport unfamiliar to the pilot, an electronically-generated moving map of the airport would be selectable through the aircraft's flight management system (FMS).

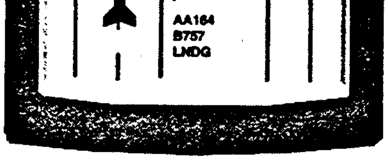


Figure 3. Cockpit Moving Map

The aircraft's position, identified from a differential global positioning satellite (GPS) derived position, would track the aircraft relative to the map. In extremely low visibilities, the copilot would monitor the map for compliance with the route, while the pilot concentrates on maintaining visual centerline guidance on the taxiway. The copilot can then give turning cues to the pilot. For single pilot aircraft operations and for some specially equipped aircraft, heads-up displays may be used to display traffic and taxi route information. The moving map can also be selected at landing, providing cues to the pilot for exiting the runway. This cockpit moving map and FMS combination can also monitor compliance with the taxi instructions and alert the pilot when a deviation from the routing occurs.

This same cockpit moving may be capable of displaying other traffic moving on the surface. This concept of cockpit display of traffic information will be a value-added benefit to the same capability in the airspace. Data link will be used to deliver information on aircraft/vehicle positions.

Surveillance

Surface surveillance must undergo significant change if automation benefits are to be realized. Surface automation requires reliable tracking and identification of both cooperative

surveillance system will use a mix of sensors to compensate for technological limitations of each type of sensor and varying degrees of aircraft/vehicle capabilities to provide complete information.

Aircraft will be equipped with cooperative system components in an evolutionary manner and benefits of airport surface automation will accrue to users as more aircraft become equipped. During the transition, a method will need to be developed for the controller to tag aircraft with an identity code. In a radar environment, this tagging of targets must consider tag ambiguity when targets merge, dropping tags when there is target shadowing and multipath false targets. Attaching identity tags must be through a computer/human interface that does not create a burden on the local or ground controller.

The only current surface surveillance capability is the airport surface detection equipment (ASDE-3) surface radar currently being deployed at 34 airports. Radar does not provide target identification and suffers from shadowing, where buildings and other aircraft can screen an aircraft's movement. Airport coverage by the ASDE-3 is designed for runways and major taxiways, but there are areas on the airport that are not covered. Variability in energy returns from the target and multipath causes tracking variability that complicates surveillance and automation.

While the ASDE-3 provides ground movement radar surveillance at the Nation's largest airports, they are not cost-effective for all airports. Alternatives using radar or other technologies will be necessary in order to aircraft target is. Without target identification, system integration of surveillance and other automation functions on the airport becomes complex and costly.

The Mode S aircraft beacon squitter can provide target identification for equipped aircraft. Mode S automatically broadcasts a signal twice a second to support airport traffic conflict alerting and can also do so on the ground. The challenges in this technology will be (1) resolving multipath issues, (2) the cost of installing and linking receiver ground stations, (3) determining whether Mode S or a derivative operating at the Mode S frequency can support global navigation satellite system (GNSS) automatic dependent surveillance (ADS), and (4) determining whether there is adequate communications capacity in dense traffic areas to support GNSS/ADS on the surface . The Mode S transponder is not required on general aviation aircraft. A communications architecture for GNSS/ADS is evolving which will include all types of aircraft.

The surveillance system of the future will still use primary radar to detect noncooperative targets, but most aircraft will become equipped with avionics supporting GNSS. This satellite-based surveillance system will be a value-added surface benefit derived from using GNSS in the air for navigation. Position reporting will include both the position and identification of the target. This position reporting can be from the aircraft to ground-based surveillance, as well as between aircraft so the pilot will know what other traffic is nearby. The avionics will require a data link for transmission of position and aircraft identity. This same data link may be used for transmission of the navigation capabilities of GNSS with data link, many new avionics product lines could be produced which have application and a greater market in other modes of transportation.

Ground vehicle surveillance with positive target identification need not be on the same data link as aircraft. The ASTA system must have the capability of processing multiple sensor data. Frequency spectrum currently allocated to ground transportation communications could be employed with either GPS-derived position reporting or by using time-of-arrival multilateration techniques. Those airport ground vehicles that frequently travel onto the runways should operate on the same system as aircraft. Vehicles not equipped with a cooperative system component would be tracked by primary radar on taxiways and runways.

The Surface Movement Display

The surface movement display integrates the output of surveillance and airport surface automation. An example of a display would be the airport configuration with digital targets. These targets could carry a data block containing aircraft call sign, aircraft type, and a time sub block that changes with the phase of operation. While sitting at the gate, the time block element contains the optimum push back time to get the aircraft to the runway for takeoff--considering route of flight, wake vortex separation requirements, and departure fix loading. Once taxiing, the time block changes to the optimum takeoff time. On landing, the time block changes to a gate number or parking spot designator.

target and runway information. Emerging display technologies which support color and are capable of operating with high contrast in high ambient light will improve the interface between automation and the controller. The FAA is currently identifying requirements for information display within TCCC, ASDE-3/AMASS, and ASTA which will lead to appropriate information display and computer/human interfaces.

Surface Conflict Alert

The airport movement area safety system (AMASS) currently under development by the FAA is the first attempt to add surface conflict alert to radar-based surveillance. The ASDE-3/AMASS combination provides the foundation for evolving to airport surface automation. With surveillance tracking of targets, safety logic can be applied to these target tracks. Warnings are issued when certain parameters are not met. For example, an aircraft cleared onto the runway to hold for departure could be forgotten by the controller. A time parameter is set in the system. If the aircraft remains in position longer than normal, an alert would cue the controller to the potential error. Likewise, if an aircraft on short final approach and an aircraft crossing the runway at midfield would result in a runway incursion, a warning would be provided to the controller who would intervene to correct the problem.

The technical concerns with surface conflict alert include the complexity of the airport configuration, procedural issues unique to the airport's operation, and the need to reduce false alarms to nearly zero for the system to be acceptable to the controller work force.

development philosophy is to incrementally add functionality, migrating from the ASDE-3/AMASS to full surveillance with target identification, traffic planning to optimize taxi routes for arrivals and departures, and taxi route conformance monitoring.

In the cockpit, the aircraft's FMS can monitor conformance to taxi instructions and clearances. Warnings and cautions detected by surface automation can be uplinked into the cockpit with data link. Both the controller and pilot receive automated safety backup and can expect to receive the same information to solve a human error in advance of a serious conflict.

Traffic Planning

In order to gain efficiencies on the airport surface, departures must be sequenced in a way that optimizes departure fix loading, considers arrival streams of traffic, and wake vortex separation requirements. The traffic planning function must consider departure and arrivals at other airports and arrival loads, nominal taxi times (by aircraft type and starting location) and delays in the departure queue. The process of pushing back from the gate must consider other traffic operating on the airport surface. By combining the nominal taxi time with the time through the queue for the airport's configuration, and considering fix loading, optimum push back times could be derived and displayed for departure aircraft. The pilot and ramp controller would work to meet that optimum time. If there are three aircraft leaving at nearly the same time, the system would mix the aircraft based on the departure fix loading to optimize sequencing, e.g., an eastbound emphasis by the airline ramp controller or dispatcher on when an aircraft should start taxiing and where the aircraft should be positioned relative to other departures in the same gate area. A time-based traffic hand off from the ASTA traffic planner to TATCA will occur to expedite airport and terminal traffic. This tactical planning and execution requires sharing of information between the pilot, the airline, and the FAA air traffic controller.

Visual Aids

Visual aids will continue to be the primary navigation aid for the pilot in surface movement. Runway visual aids are not expected to change; however, marking, lighting, and signage on taxiways will go through a significant evolution. Marking and signs will be directly tied to the category of the airport approaches. Those airports that support low-visibility operations will make a significant capital investment in visual aids. Small general aviation airports, which today have little or no taxiway marking and signage, will begin to install visual aids to benefit student pilot training and prevent runway incursions.

The most substantial change will occur in airfield lighting. The continuing complaint of pilots during night surface navigation is confusion caused by the "sea of blue lights." This condition will be mitigated by use of segmented lighting circuits that allow lighting of only those segments of taxiways necessary for aircraft operations. Lighting will be tied to the airport configuration, as opposed to the current condition where most or all taxiway lights are controlled by the same switch. When the configuration of the runways change, the set up of the lighting system surface sensors and trip beams to activate taxiway lighting segments as the aircraft approaches the next segment. The lighting segments will be set automatically, based on the configuration and the airport surface traffic surveillance system. Computerized lighting control systems will be able to address each lighting segment individually. The air traffic controller will be able to selectively sequence the lighting of designated taxi routes through automation.

Taxiway centerline lighting will also use segmented lighting and control using signals that travel along the power circuit and activate segments sequentially to provide progressive route guidance. Each segment will be individually addressable by automated lighting controls that integrate information on the intended route of travel with the ASTA surveillance components.

Power will likely continue to be constant current systems, but their control will rely more on automation. Failure modes will be defined so that power failures, computer failures and component failures can be isolated and the system quickly recovered.

Runway Status Lights

A new lighting system undergoing proof-of-concept testing involves two lights on either side of the taxiway at the taxiway/runway intersection. They would make wig-wag lights obsolete because they would be turned on by surface surveillance and indicate when the runway was hot. This concept works much like how railroad crossing lights work. Red pulsing lights would illuminate, indicating that it was unsafe to enter or cross the runway because another airplane is taking off or landing.

with automated activation. They will surround the airport runway, acting as traffic lights for crossing or entry onto the active runway. While initial installations require activation of switches by air traffic controllers, stop bars will become fully automated through an interface between lighting control automation and ASTA. Given that the ASTA system is installed and knows which aircraft is where on the airport surface, the controller can issue a clearance, voice recognition technology will capture controller intent through the clearance, and ASTA will determine if the aircraft is next in line to enter the runway. ASTA will then tell the lighting system to turn off the stop bar line at the intersection, turning off the stop bar lights, allowing access to the runway. The lights will be reactivated by the aircraft passing a surface sensor.

Land-Hold-Short Lighting
Lights located at the intersection of two runways will provide the pilot with visual cues to improve landing and deceleration to stop short of another runway being used for takeoff or landing. These in-pavement lights will initially be turned on by the controller based upon the controller's intent to conduct land-hold-short operations. The control of the lights will evolve to using automation and controller intent for each operation to activate the lights so that they are only on when operations are being conducted on the two intersecting runways.

Taxi lane to the Gate
For low visibility operations, centerline lighting along taxi lanes and radius-of-turn lighting will be used to aid in guiding the operations and the ramp controller. Data such as way points for navigation, weight and balance, weather, route of flight information, and ATC clearances can travel over this gate LAN, directly into the flight management computer. Likewise, aircraft maintenance and other administrative activities can flow to and from the aircraft on the LAN.

Simulation
Simulation will play an increasing role in day-to-day operations on the airport. Simulation models will be used by the airport operator to assess capacity impacts of proposed construction activities, emergency response and disaster planning, snow removal strategies, moving passengers through their facility, and noise abatement procedures. The airline will use operations research techniques to optimize schedules, tactical push back decision making, and even alternative service strategies to improve aircraft turnaround times. While simulations will initially be done by consultants, the ultimate goal is to allow employees to play "what if" scenarios to explore quality of service improvements.

Within the control tower, simulation will become a powerful tool in training, evaluating new local procedures, fine-tuning surface efficiency, and replaying scenarios to evaluate safety performance. This simulation capability will be modular, include local, ground, and clearance delivery positions, and operate off live or recorded surface situational data taken from the ASTA system. By adjusting the traffic volume the system can simulate an increase in the controller work load, inject targets for training exercises, or modify traffic routing to evaluate efficiency.

like a commercial airline pilot does today, to deal with complex situations, capacity constraints, emergencies, and identify their personal and team performance strengths and weaknesses.

efficiency. The capital investment in surface systems will require aviation community consensus to developed a transition to increased surface automation to support traffic growth and efficiency.

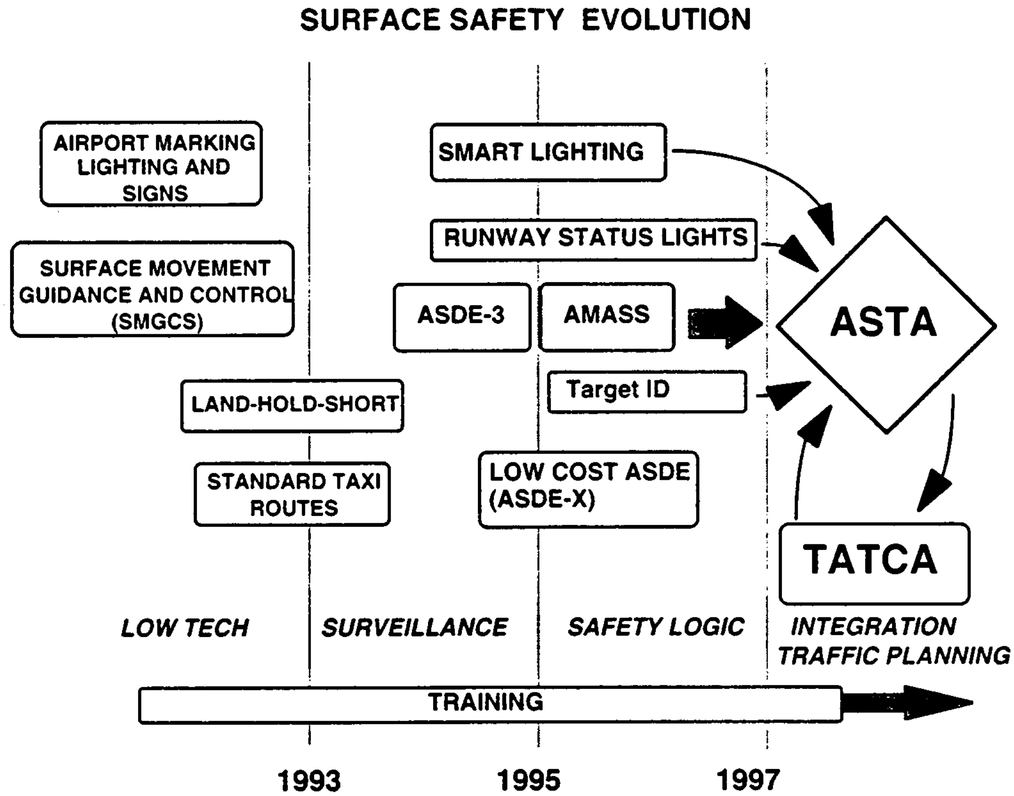


Figure 4. Surface Movement Capabilities

Reaching Aviation Community Consensus

The development of a detailed future system design is an aviation community/FAA joint activity. System design features that offer operational advantages for one group of users may affect the capital investment of another. The community must have a thorough understanding of alternatives and time frames for transition. This future concepts vision is only the starting point. Operational concepts for application of technology and procedural improvements must be developed. Operational requirements must be defined, followed by a plan for transition.

The aviation community and the service providers must be convinced that the

International Considerations

The airport is the meeting place for global aviation. International users operating in the United States should be able to operate without constraints caused by different avionics. Likewise, aircraft operating overseas should be able to take advantage of their own surface movement avionics. International harmonization becomes a significant issue in managing change. Open sharing of visions, technical and operational exchanges, cooperative research, and work within the International Civil Aviation Organization (ICAO) will be necessary. This global technology leadership for improving airport surface movement is not unlike the challenges already faced in the future air navigation and surveillance effort underway within ICAO.

organizations that focus on aircraft avionics or air traffic control systems must reach out and solicit input from the airport community on adapting existing systems or creating new systems that can improve safety and efficiency on the airport surface.

This future vision is only a starting point. Operational concepts for application of technology and benefits must be defined in cooperation between the National Airspace System users, airport operators, and the FAA. This vision will lead to development of operational requirements for surface movement, followed by the necessary plan defining the time frames and resources required to realize system benefits.

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